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ELEMENTS OF CHEMISTRY

BY J. C. SMITH

NEW YORK: J. C. SMITH, 1874.



THE
ELEMENTS OF CHEMISTRY;

EMBRACING

THE GENERAL PRINCIPLES,

AND REFERENCES TO THE

MOST IMPORTANT APPLICATIONS OF THE SCIENCE,

WITH A DESCRIPTION OF THE

CHIEF INORGANIC AND ORGANIC SUBSTANCES,

IN ACCORDANCE WITH

RECENT DISCOVERIES AND PRESENT THEORIES.

ILLUSTRATED BY ENGRAVINGS,
AND SEVERAL HUNDRED EXPERIMENTAL OPERATIONS.

TO WHICH IS ADDED,

A COPIOUS GLOSSARY AND INDEX.

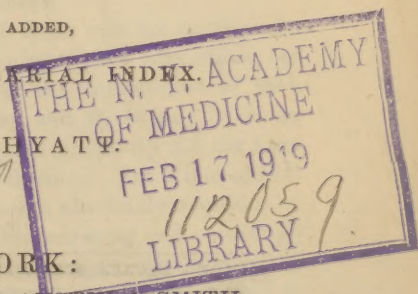
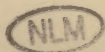
BY JAMES HYATT.

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1855.



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PREFACE.

SOME knowledge of Chemistry must undoubtedly be regarded as an indispensable part of a common education; and the young person, of either sex, who now discontinues study without having learned the chief facts and principles of this important science, will scarcely have a fair claim to belong to the *educated*, as distinguished from the *ignorant* class.

His stock of information, for example, can not be extensive, who does not know the elements of the water he drinks, nor those of the salt and bread, before him on the table.

Such ignorance, though allowable a century ago, when this knowledge was unknown, will not much longer be tolerable, when school-books contain the details of the composition of most common natural and artificial substances.

It is very true, that a majority of those who are in respectable stations in life, and who have enjoyed fair educational opportunities, are, perhaps, ignorant of the composition of such common things as bread and butter; and there may be some excuse for it in this, that the elements of Chemistry did not form a part of their regular studies when at school; but if it is considered, that very many chemical facts are absolutely requisite to an understanding of such things as the *warming and ventilating of buildings, the preparation of food, the proper regulation of the diet, and of the commonest phenomena in surrounding nature, to which we are intimately related*, it must be admitted that all who are ignorant of these facts, whether young or old, now that the task is easy, and every facility for the study is at hand, should

set to work to learn them; and this, not merely for the credit of their reputation as respectable and intelligent persons, but as a matter of health, economy, and pleasure.

Indeed, ignorance of this kind is inconsistent with intelligence, it can not command respect, and is very unprofitable, pecuniarily, hygiënically, and even morally.

Then, as chemical principles have applications in every art, manufacture, and branch of industry, including eminently that most extensive, healthful, profitable, and fundamental of all arts, *the Culture of the Soil*, we see the importance of a knowledge of these principles, not merely to those who are engaged in such arts, and to every moderately-educated person; but as a part of the common school lessons of the people.

Particularly is this knowledge important to those who superintend the labors of rougher hands, and more untaught minds, as of the domestics in our houses, and the workers in our factories and fields, who, unfortunately for all, have little science, and depend almost entirely on their unenlightened experience.

Every head of a family stands in absolute need of considerable correct chemical information; and one would suppose, that of those who associate with intelligent people, and thus have opportunity to learn the economies of life, they who neglect to study nature and especially Chemistry to a reasonable extent, would be only those who are content to live by chance and the sufferance of the elements, like the moth that flutters in the bright sunshine on the day of its birth, and then, by plunging into the first blaze that attracts it after nightfall, mistakenly destroys itself before it has accomplished the end of its existence.

Such persons are truly, in comparison, more improvident than the careless moth; for these animals, destitute of reason, and with but a slight portion of instinct, still live according to the laws and by the will of the Great Creator who has furnished *us* with higher faculties, expressly that we might employ them to study and improve our condition. If we neglect this, we are less worthy than they; nay even criminal for our thoughtless stupidity.

To the ruder laboring classes, and to their children, the study of Chemistry would be highly advantageous. It would render their labor more effective; it would assist to destroy that neces-

sity for the constant supervision of more intelligent minds which is the chief cause of the low price and little value of their toil.

These classes should know, that the constant progress of scientific discovery, of invention, and that continued extension and improvement in machinery which it is impossible, if it were desirable to arrest, tends to render of less and less value mere physical labor which is not associated, in the laborer, with superior skill and intelligence; so that the only escape from a starving competition against iron hands and sinews, impelled by steam or water, or pure brute force, lies in the study of the principles upon which art depends and machinery is driven and constructed; a study which shall raise the student from among the untaught throng, and by diminishing their number, increase the price they obtain for the sale of their sinews.

To bring the ignorant to know this necessity for their acquisition of knowledge, and to teach them this knowledge, is the business not only of the philanthropic, but it is the duty and the interest of the more intelligent classes. It is indispensable to society that this should be done; and it is to be accomplished partly by means of our public schools.

The time has already come, when many of the laboring classes see, that their children require more than a knowledge of their language, of arithmetic, and of civil geography. They, as well as those having the management of their schools, perceive the necessity for the study of natural science, the public press urges the value of a knowledge of chemistry, and the study is now being introduced, and will very soon be regularly pursued, in all schools of the grammar-school grade.

The private schools, in which are taught those of our sons and daughters who enjoy their peculiar advantages, will be compelled to increase their facilities for these studies, lest they and their pupils fall to an inferior position in public estimation.

Beside, Chemistry is requisite for a proper knowledge of other sciences. Geology, Physiology, Pathology, and Physical Geography, could never have reached their present development without its aid, nor can they be fairly understood independently of some previous acquaintance with chemical principles.

Mining is closely connected with Geology; Metallurgy is purely a chemical art; Medicine is based on Physiology and

Pathology, and its remedies are mostly chemical preparations ; trade and commerce and civilization, even, are closely related to physical geography ; so that Chemistry is intimately interwoven with the most important and profitable material professions and pursuits.

And while Somatology, Mechanics, and Physics, are introductory to Natural Science, Chemistry is the key by which the mysteries of nature are unlocked ; and at this age of the world some study of it should be regarded as indispensable to every person.

NOTE.—The writer would here acknowledge his indebtedness to the various Chemical publications and authorities which he has been obliged to consult. The Scientific Journals, as the *Comptes Rendus*, the *Annales de Chimie et de Physique*, the *American Journal of Science and Arts*, the *Edinburgh New Philosophical Journal*, the *Chemical Gazette*, the *Chemist*, the *Lond., Ed., and Dubl. Philosophical Magazine*, &c., have occasionally assisted him ; also, the treatises of *Gmelin*, *Kane*, *Fownes*, *Silliman*, and others, have been frequently referred to.

The observations, &c., of *Mr. T. Sterry Hunt*, in *Silliman's Chemistry*, and elsewhere, have been found very correct and valuable.

INTRODUCTION TO TEACHERS.

OBJECTS AND PLAN OF THE WORK.

IN the compilation of this work, the writer has introduced a sufficient description of the more important chemical substances, a reference to the leading principles of the science, and as far as it was thought advisable, has noticed its most valuable applications.

He has besides endeavored to systematize the study, without however rendering it too formal, and to present the subject in such a manner that the learner will be able to obtain a sort of perspective view of the plan and scope of the science.

Some peculiarities will doubtless be noticed. The subject has been stripped of everything that does not strictly belong to it; and the learner without having become fatigued with a tedious introduction, commences immediately with the proper study of the science.

By this means, and by omitting the more unimportant substances, and much of the usual heavy detail, the book has been brought within such limits, that it can be easily mastered before the learner has lost interest in the new study. This leaves him a disposition, as opportunity offers, to resume the subject and pursue it in more extensive works.

It will be seen also, that all the simple substances are referred to, and described as far as necessary, before the commencement of a special description of compounds. This gives much greater simplicity to the study; it fixes the simple substances, as such,

in the mind; and the writer from long experience, has found this course much more successful.

The simples have, to some extent, been arranged in groups.

The compounds also are studied in classes; those of the simplest constitution, as the Binary compounds, are first introduced, and among these, the classes of Hydracids and Haloid salts, are separately noticed.

The Oxyalts are mentioned in connection with their acids; thus Sulphuric acid and the Sulphates are brought together; also Carbonic acid and the Carbonates, and so with others as far as they have been noticed. This is thought to be the most natural arrangement, and to tend to give the learner plainer and more comprehensive views.

Besides, those substances that are most alike in properties or composition are thus brought together, the learner becomes familiar with the type of each class of compounds, and the attention in the course, is repeatedly directed by this arrangement, to the same substances, so that while there is very little real repetition, its full advantage, in making durable impressions is secured.

The arrangement of *the organic portion* of the subject, will facilitate, it is thought, the study of the extensive and important relations which this has to animal and vegetable life. Here however it was necessary to be brief; and the whole work is indeed but a skeleton, or outline, serving as is hoped as a basis for more extended studies.

It has been intended to make the work, as much as possible, the commencement of a practical study of the things and principles described; and not an independent abstract of words and ideas.

Chemistry is eminently a material science; and the things of which it treats, should be before the mind and the eye. To facilitate this, the substances described, and the operations performed in a course of "experiments," are referred to distinctly and separately, under the title of *ocular illustrations*, and numbered, as such, from the beginning to the end of the book.

It is scarcely necessary to say, that this should be realized as much as possible, by means of a *Cabinet of Specimens* of chemical substances more or less complete, and *simple appa-*

ratus and material to some extent. These are within the reach of every energetic teacher; while facilities for extending these valuable aids in teaching are constantly increasing. The *glossarial index* at the end of the book, will be found very complete. *The writer has endeavored to define correctly, at least every chemical term and principle* referred to, not found in good English dictionaries, so that while the treatise is not large, it will, it is hoped, be found tolerably perfect, and quite convenient and comprehensive as far as it goes.

Confiding his work to the intelligent and independent judgment of his fellow teachers, the writer will be truly gratified if, meeting their approval, it shall be found to supply an educational want; to aid the practical instruction of the young, and to promote, however moderately, the diffusion of a knowledge of the most eminently useful of all the material sciences.

NOTE.—Teachers can, at their discretion, omit in giving out the lessons, the questions included in brackets, as these refer to explanations in small type in the text.

ELEMENTS OF CHEMISTRY.

Fig. 1.



An Oak-Tree.

PART 1.—INORGANIC CHEMISTRY.

ARTICLE 1. CHEMISTRY is the key to a knowledge of both Nature and the Arts.

It assists, for example, to explain the mystery by which an acorn becomes a magnificent oak (fig. 1), building itself up, and annually extending its stately trunk and numberless branches, by drawing its chief nourishment from the invisible air; and it

ART. 1. To what is Chemistry the key? What mystery does it explain? From what does an oak draw its chief nourishment?

Fig. 2.



A Daguerreotype Profile.

has also assisted to perfect the beautiful *photographic art*, by which a portrait (fig. 2), or a landscape, may be daguerreotyped to a perfect resemblance of reality.

Chemistry has greatly contributed to aid many of the most important modern inventions and improvements. Thus, the galvanic battery, in which various chemical substances are employed, and chemical changes are in continued action, furnishes the agent for the operation of the Electric Telegraph.

2. Still, Chemistry is eminently a *modern science*. Many of the most important elements have been dis-

covered, and nearly all the chief principles established, since the middle of the eighteenth century.

Carbonic acid was first described by Dr. Black, in 1757; Nitrogen, by Rutherford, in 1772; Priestley discovered Oxygen in 1774; Chlorine was first noticed by Scheele, the same year; Hydrogen, by Cavendish, in 1776; and Potassium, and other metals of the alkalis, were discovered by Davy so late as 1807.

The nomenclature, the equivalents, etc., the results of the labors of Lavoisier, Berzelius, and others, are of similar date; while the investigations of Liebig, Boussingault, &c., in Organic Chemistry, are still more recent.

Chemistry is intimately related to human necessity, comfort, health, and life. It assists us to sources of nutritious food, to manufacture clothing and furniture, and to know what substances, as the various solids, liquids, and gases, are beneficial or poisonous.

A science that, comparatively, is little studied, it is capable, when more generally understood, of increasing to an incalculable extent the wealth of the world.

3. *Chemistry has three general objects.*

Firstly. It discloses the composition of substances; as, for example, that *water* consists of Oxygen and Hydrogen.

What art has Chemistry assisted to perfect? What aid has this science rendered? What is said of the galvanic battery?

2. Why is Chemistry called a modern science?

[Mention the discoverers of Carbonic acid, Nitrogen, Oxygen, Chlorine, Hydrogen, and Potassium. Of whose labors are the nomenclature and the equivalents the results? Who have made investigations in Organic Chemistry?]

To what is Chemistry intimately related? To what does it assist us? What is Chemistry capable of doing?

3. How many general objects has Chemistry? What is the first-mentioned object of the science? Of what does water consist?

Illustration 1. Hydrogen exhibited as a combustible gas.

Ill. 2. In Oxygen, ignited, wood suddenly inflames:

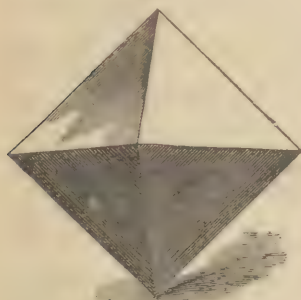
Secondly. Chemistry describes the means by which substances are separated into their elements, or by which elements are united into compounds.

Ill. 3. By the aid of *heat*, Carbonic acid, one of the elements of chalk, is expelled, and Lime is left; and, by means of *attraction*, Carbonic acid and Lime, in separate solutions, combine, when the solutions are mixed, and again form *chalk*.

Thirdly. Chemistry describes the peculiar or distinctive forms and properties of bodies.

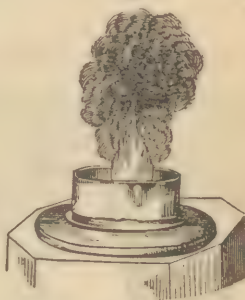
Ill. 4. The Regular Octahedron (fig. 3), a solid having eight equilaterally triangular faces, is a natural form of the diamond, and is peculiar to it and to some other minerals.

Fig. 3.



Regular Octahedron.

Fig. 4.



Potassium burning on Water.

Ill. 5. A distinctive property of Potassium is, its production of fire on water (fig. 4).

4. *The Chief Operations in Chemistry are Combination, Decomposition, Solution, and Precipitation.*

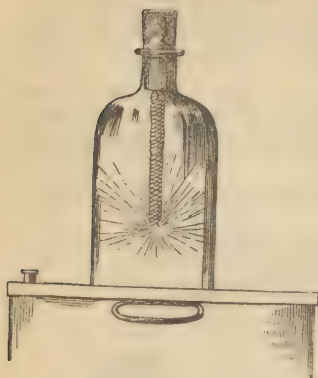
Combination is the uniting together of two or more *different* substances to form a new substance.

Ill. 6. Iron burned in Oxygen (fig. 5). They combine, and form Oxyd of Iron. See Art. 177.

What does *Ill. 1* show of Hydrogen? *Ill. 2* of Oxygen? What object of the science is mentioned *secondly*? By what means may Carbonic acid be expelled from chalk, and what is left? What is mentioned *thirdly* as the business of Chemistry? What does *fig. 3* represent? What often has naturally the form of the regular octahedron? How many and what faces has a regular octahedron? What is shown by *Ill. 5*?

4. What are the four chief operations in Chemistry? In chemical *combination*, are the substances that combine alike? What sort of substance is formed by chemical combination? What is shown of Iron in *Ill. 6*?

Fig. 5.



Iron burning in Oxygen.

formed, it is *Simple Solution*, as in the last case; but when combination also occurs, it is *Chemical Solution*.

Fig. 6.



A Test-Glass.

Chemical combination always produces heat. *Fire* is the light and heat resulting from very rapid combination.

Decomposition is the separation of a substance into its elements; as of chalk into Lime and Carbonic acid.

Combination and Decomposition are the only processes that are invariably and purely chemical.

5. *Solution* is when a substance is dissolved in a liquid.

Ill. 7. Sulphate of Copper (blue vitriol), dissolved in water.

When there is no change in properties, and no new substance

Ill. 8. Ammonia water thrown into a simple Solution of Sulphate of Copper; a magnificent blue chemical solution of Ammonia Sulphate of Copper formed.

6. *Precipitation* is the separation of solid particles from a clear solution.

Ill. 9. On pouring water into a strong alcoholic solution of Camphor gum, the Camphor is mostly precipitated.

Ill. 10. By mixing in a test-glass (fig. 6) a solution of Nitrate of Silver and one of Chlorid of Sodium (common salt), there are two decompositions, new compounds are formed, and one of them, the Chlorid of Silver, is precipitated.

7. All substances are either compounds or simple substances.

Simple substances are those which are incapable of suffering decomposition. More than

What does chemical combination always produce? What is fire? Describe decomposition, and give an example. What are the only processes that are wholly chemical in all cases?

5. What is *Solution*? What is done with Sulphate of Copper in Ill. 7? What is simple solution? When chemical combination is connected with solution, what is it called? What chemical solution is formed in Ill. 8?

6. What is *Precipitation*? How is Camphor precipitated in Ill. 9? In mixing, in Ill. 10, solutions of Nitrate of Silver and Chlorid of Sodium, what is the result?

7. How are all substances classified? What is a simple substance?

sixty such substances are known. Sulphur, Silver, and Lead, are examples. Compounds are those which may be decomposed; as Water, Chalk, and common salt.

8. The simples are either metals or non-metals.

A *Metal* is a simple substance that receives a lustre by polishing, and that is a good conductor of heat and electricity. Hence the use of metals, such as Iron and Copper, for stoves, boilers, telegraph-wires, etc.

A *non-metallic* substance is one that is not a good conductor of heat and electricity.

There are fourteen non-metallic simples, such as Iodine, Chlorine, Oxygen, and Carbon.

Ill. 11. List of the non-metals, written on the black-board in large letters, or printed and suspended on the wall. See Art. 88.

The first simple to be noticed is—

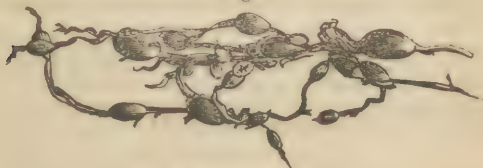
IODINE.—SYMBOL I.

Equivalent 127. *Specific Gravity** $\left\{ \begin{array}{l} 8.7 \text{ Air } 1. \\ 4.9 \text{ Water } 1. \end{array} \right.$

9. *Iodine* exists most abundantly in sea-water, and in marine plants and animals. It is extracted from kelp, the ashes of seaweed. It is never found naturally in a *free*, that is, an uncombined state.

Ill. 12. Common bladder sea-weed, fig. 7 (*Fucus vesiculosus*).

Fig. 7.



Fucus vesiculosus.

* Different degrees of density, or variable quantities of matter in equal spaces, gives rise to Specific Gravity. The sp. gr. of a solid or liquid is the

How many simples are known? Mention some simples. Define compounds, and give examples.

8. How may the simples be classified? Define the term a Metal, and give examples. What is a Non-metal? How many non-metallic simples are there? Read off the list of Non-metals. What non-metallic simple is first described, and what is its symbolic letter?

9. Where is I. found? I. is extracted from what? Is I. naturally free? What is *Fucus vesiculosus*, shown in *Ill. 12*?

[What gives rise to specific gravity? What is the specific gravity of a solid or liquid?]

I. is a blackish solid,* usually seen in flat crystals of a brilliant lustre.

Ill. 13. Specimen of I.

It takes its name from its beautiful violet vapor. The Greek word, *iodes*, signifying like a violet.

Ill. 14. I. vaporized in a flask by heat. The violet vapor, on cooling, forms minute crystals lining the flask.

I. is slightly soluble in water, but dissolves in large quantity in Alcohol and Ether.

Ill. 15. I., by dissolving, gives to water a slight, and to Alcohol a deep color.

10. I. has strong affinities, that is, tendencies to combine. When it combines with a simple, the compound is generally called an Iodid.

Ill. 16. I. unites with Phosphorus, forms Iodid of Phosphorus, and kindles a fire.

11. The presence of I. when in solution, in an uncombined state, is shown by Starch. If the I. is combined it must be lib-

weight of a certain bulk of it in comparison with that of an equal bulk of water; while the sp. gr. of a vapor or gas is found by comparing with air. Zinc is 7 times as heavy as water; its sp. gr. is 7. A quart of Carbonic acid gas weighs $1\frac{1}{2}$ times as much as a quart of air; the sp. gr. of Carbonic acid gas is 1.5.

* Bodies exist, in respect to solidity, in two general forms: *solids*, like wood, stone, and dust; and *fluids*, or those of which the particles can readily flow about.

The fluids are divided into *liquids*, or visible fluids, like water and oil; *vapors*, or invisible substances, liquefied by atmospheric cold and pressure; and *gases*, or more permanent invisible substances, not liquefiable by ordinary cold and pressure, like air and Oxygen. Wood, water, steam, and air, are representatives of the four forms—the *solid*, the *liquid*, the *vapor*, and the *gas*.

What form and appearance has I.?

Why is the name of I. derived from *iodes*? Describe the vaporization of I. in *Ill. 14*. In what is I. soluble? What is the effect of I. on its solvents in *Ill. 15*?

10. What is meant by affinities? What sort of affinities has I.? What is a compound of I. called? In *Ill. 16*, what is the action between I. and Phosphorus?

11. What shows the presence of I. when in solution in a free state?

[Why is the sp. gr. of Zinc said to be 7? How is the sp. gr. of a vapor or gas found? Mention a gas that is $1\frac{1}{2}$ times as heavy as air.]

[What two general forms have bodies? What can the particles of fluids do? Mention the three kinds of fluids and their characters. Mention the four forms of bodies and their representatives.]

erated before the starch will act, or else some other agent, such as Chlorid of Mercury must be used.

Ill. 17. Cold Starch water and a weak aqueous solution of I. produce a purple Iodid of Starch.

The compound of I. and Starch is called an Iodid, since the Starch here acts like a simple. See Iodids in Art. 10.

Ill. 18. Solution of Chlorid of Mercury and of Iodid of Potassium mixed. Brilliant red Iodid of Mercury precipitates, and Chlorid of Potassium remains in solution.

Test. Reagent. The means by which a substance is separated, precipitated, or recognised, is termed a test for that substance. Any chemical substance used in testing is a reagent. Starch and Chlorid of Mercury are tests for I.

12. Uses. I. is used in medicine; and it is employed in photography because it acts on Silver and forms Iodid of Silver, which is decomposed by light.

Ill. 19. I. on a bright silver coin. Dark colored Iodid of Silver formed on its surface.

I. decomposes animal and vegetable tissues and therefore is an active poison.

13. Chemical substances combine in fixed ratios; for example, the Oxygen and Hydrogen in water are always in the ratio of 8 to 1, and nine pounds of water contain eight pounds of Oxygen and one of Hydrogen. Iodine and Hydrogen combine in the ratio of 127 to 1.

Hydrogen is the most common standard of comparison in respect to ratios of combination. 127, therefore, is the ratio of combination, or as it is commonly called the *Equivalent* of Iodine. Briefly, then, an equivalent of a simple substance is the quantity of it by weight that will combine with one part of Hydrogen, or with as much of any other substance as will combine with one part of Hydrogen; and the equivalent of a compound is the sum of the equivalents of its elements; thus, as seen above, the equivalent of water is 9.

The second non-metallic simple to be noticed is—

What is the action of Starch on I. in *Ill. 17*? Describe the reaction between Iodid of Potassium and Chlorid of Mercury in *Ill. 18*. What is a test? A reagent? Mention tests for I.

12. Use of I.? Why employed in Photography? I. why poisonous? Describe the action of I. on silver in *Ill. 19*.

13. Tell how chemical substances combine in respect to quantity, and give an example. What do 9 pounds of water contain? In what ratio do I. and Hydrogen combine? What is the standard for combining ratios? What number is the equivalent of I.? What is the equivalent of a simple substance? Of a compound? What is the second non-metallic simple noticed and what is its symbol?

BROMINE, Br. *Equiv.* 80. *Density** $\begin{cases} 5.39, & \text{Air } 1. \\ 2.97, & \text{Water } 1. \end{cases}$

14. Br. like I. exists naturally only in a state of combination. It is generally present in saline waters, and is commonly extracted from sea water. Br. is a deep red liquid, and except Mercury, the only simple that is usually liquid. It is so volatile as to escape in vapor from an open vessel. It is soluble in water but more so in Alcohol and Ether.

It has a very pungent and offensive odor, and from this it takes its name, which is derived from the Greek, *bromos*, a stench.

Ill. 20. Specimen of Br.

Ill. 21. Br. converted into a bright red vapor.

Ill. 22. The vapor dissolved in water which it colors.

15. Br. has very powerful affinities, since it combines rapidly with metals and with all combustible simples. Its compounds with other simples are mostly called Bromids. It quickly destroys animal and vegetable tissues and is therefore very poisonous. One drop on a bird's beak will soon cause death. It will take the edge from a steel file. It acts differently from I. on Starch.

Ill. 23. Detonation of Br. when dropped by a glass rod on small bits of Potassium; Bromid of Potassium formed.

Ill. 24. Br. inflames Phosphorus.

Ill. 25. Orange color given to Starch by Br.

16. Br. is used in Photography because it will unite with the Silver of the Daguerreotype plate to form Bromid of Silver which is decomposed by light.

Ill. 26. Specimens of Daguerreotypes.

Ill. 27. Br. corrodes Silver and forms Bromid of Silver.

The third non-metallic simple to be noticed is —

* Density is here used instead of *Specific Gravity*.

14. What is the natural state of Br.? Where is Br. found, and from what obtained? Color and form of Br.? What other simple is generally in the liquid form? Volatility of Br.? Its solubility? Why does Br. take its name from the Greek word, *bromos*? In *Ill.* 21, what is the color of Br. vapor? In what is the vapor dissolved, *Ill.* 22?

15. Why is Br. said to have powerful affinities? What names have the compounds of Br.? Action of Br. on living tissues? On a bird's beak? On a file? In *Ill.* 23, how does Br. act on Potassium? On Phosphorus, 24? On Starch, 25?

16. Why is Br. used in photography? How does Br. act on Silver, 27? What is the third non-metallic simple noticed, and what is its symbol?

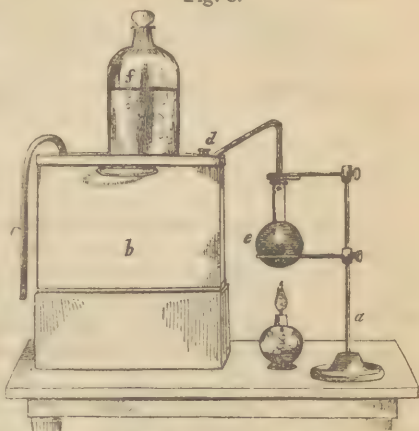
CHLORINE, Cl. *Equiv.* 35.5. *Density*, 2.47, *Air*, 1.

17. Cl. is a very abundant simple, found in all salt waters. Common salt contains Cl. and consisting of two elements, only, Chlorine and Sodium, is called, therefore, Chlorid of Sodium.

For manufacturing purposes Cl. is extracted from common salt, but for chemical illustrations it is taken from "spirit of salt" which is properly called Chlorohydric acid.

Fig. 8.

III. 28. Cl extracted from Chlorohydric acid, HCl. by means of Binoxid of Manganese MnO_2 and heat, and then collected over water, as in fig. 8. About three parts by weight of the commercial solution of Chlorohydric acid, commonly known as muriatic acid, and one part of the Oxyd may be used.



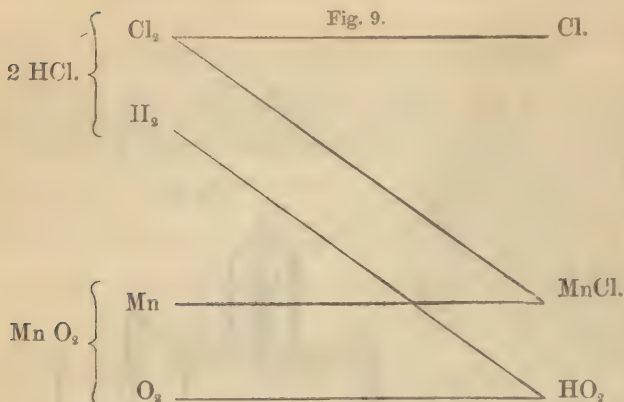
Collection of Cl. over Water.

In this process Chlorid of Manganese, $MnCl$, and Oxyd of Hydrogen (Water), HO , are formed, as shown in the diagram (fig. 9, page 20), the changes being between *two equivalents* of Chlorohydric acid and *one* of Binoxid, which are represented at the left of the brackets. The elements of these two compounds are symbolized within the brackets, and the new substances are at the extreme right.

In reference to the use of symbols, it is to be understood, that a large numeral, standing before several symbolic letters, multiplies them all (as far as

What is the equivalent and what the density of Cl.?

17. Abundance of Cl.? Cl. is found where? What substance contains Cl. and Sodium, and what is its chemical name? What furnishes Cl. for manufacturing purposes? For chemical illustrations? Correct name for Muriatic acid? By what means is Cl. extracted from Chlorohydric acid in III. 28? What does the Cl. displace when collected over the pneumatic trough? What two new substances are formed when Cl. is extracted from Chlorohydric acid, and what are their symbols? Explain the diagram? What does $2\ HCl$ represent? What is MnO_2 and of what is it composed? Whence come the elements of the water formed? And of the $MnCl$? State the different uses of the large and small numerals? Where, in the diagram, are the substances used represented? their elements? the new substances?



Chemical Changes in obtaining Chlorine from Chlorohydric acid.*

the first point), while a small numeral, after a symbol, multiplies only the one to which it is annexed. Thus, 2 HCl signifies two equivalents of Chlorohydric acid, consisting of two equivalents of Chlorine, Cl_2 and two of Hydrogen, H_2 ; and Binoxide of Manganese is represented by Mn O_2 , since it contains one equivalent of Manganese, Mn , and two of Oxygen, O_2 .

Equivalents must not be confounded, with *parts by weight*, for an equivalent of Chlorine is $35\frac{1}{2}$ parts by weight.

For a table of equivalent weights see the index.

Perhaps some further description of the process for collecting Chlorine, as exhibited in fig. 8, may be necessary. The materials are placed in the glass flask (*e*), which must not be more than half full. The gas is liberated by the assistance of a very slight heat from the alcohol lamp below. The gas proceeds from the flask through the bent glass tube at the top. This tube makes an air-tight joint with the flask by means of a cork. A vessel of water (*b*) called on account of its use for such purposes, a *hydro-pneumatic cistern*, is raised, if necessary, sufficiently high above the table, by a block. This pneumatic cistern or trough has a shelf supporting the bell glass (*f*), which is also, at first filled with water. The bell glass has no bottom, the water in it being sustained by atmospheric pressure, upon the surrounding water in which it stands. The gas being delivered by the bent glass tube from the flask, at a point in the water close beneath the bell, rises in bubbles, and displaces the water.

The shelf on which the bell stands is perforated, for the gas to pass through, or the bell may project beyond the edge of the shelf sufficiently to receive the gas.

This description and figure will apply wherever gas is collected over water; though in some cases more heat, and in others none at all, will be required.

The cistern may conveniently have, instead of a simple shelf, a movable air chamber, about half as large as itself, but not so high at the top by an

* Similar diagrams may profitably be drawn on the black-board to illustrate chemical changes in other cases.

[Distinction between *equivalents*, and *parts by weight*? Example? What name for the vessel of water used in the collection of gases? What maintains the water in the bell glass?]

inch or so, closed above, and without a bottom. This chamber may have two openings, one by the stop-cock (*d*), to let out air, and thus lower the water in the cistern, and another by the flexible tube (*e*), connecting with a metallic tube at the top of the chamber, that terminates an inch above the bottom of the cistern. As this tube always has its lower end immersed in the water, it never needs to be otherwise closed, and when air is blown through it from the mouth, the water is expelled from the chamber, and thus its level in the cistern is raised.

The air chamber is confined from rising by a bolt and is held from moving laterally by rods soldered to the sides of the cistern. In some cases this chamber having been allowed to fill with water may be employed as a reservoir for gas, the stop-cock (*d*) being kept closed, but opened when necessary to let out the gas.

All gases, only moderately soluble in water, may be collected in bell glasses and inverted bottles over such a cistern. Any bucket, pail, or tub, may easily be supplied with a shelf and used for a hydro-pneumatic trough.

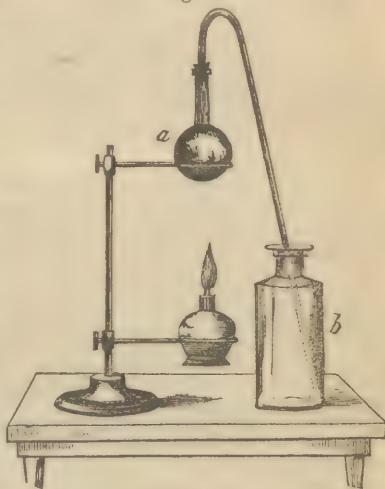
18. Cl. in form, is usually a gas, but it is liquefied by a pressure of 5 atmospheres or 75 pounds to the inch. It is soluble in half its bulk of pure ice-cold water. The solution may be frozen, when the crystals formed contain ten equivalents of water to one of Cl.

Fig. 10.

Cl. has a yellowish green color, hence its name from the Greek, *Chloros*, signifying greenish yellow. Cl. has an astringent taste and powerfully pungent and suffocating odor. It is nearly $2\frac{1}{2}$ times as heavy as air.

Ill. 29. Cl. collected by displacement of air, as in fig. 10, by carrying the delivery tube to the bottom of an upright jar, and full of air, muffled at the mouth by a perforated card.

Ill. 30. Cl. dissolved in water, by collecting the gas in a bottle over water, till it is one half filled with the gas, then closing the bottle with the palm of the hand and shaking it briskly, as the gas dissolves a vacuum is formed and the bot-



Chlorine collected by displacement of Air.

[Description of the air chamber? Use of the opening by the stop-cock (*d*)? How is the level of the water raised in the cistern?]

18. What form has Cl.? How liquefied? Solubility of Cl.? When the solution of Cl. is frozen what do the crystals contain? Why does Cl. take its name from the Greek word, *chloros*? Taste, odor, and heaviness of Cl.? Describe the collection of Cl. by displacement of air in 29, fig. 10? Also its solution in water, 30, fig. 11?

Fig. 11.



Solution of Cl. in Water, the bottle held to the hand by atmospheric pressure.

tle is held to the hand by atmospheric pressure as seen in fig. 11.

19. The chemical affinities of Cl. are very energetic. It combines with all the other simples forming, for the most part, Chlorids. It combines with Gold and forms soluble Chlorid of Gold.

Ill. 31. Phosphorus ignites spontaneously in Cl. combines with the Cl., and forms Chlorid of Phosphorus, PCl_5 .

Ill. 32. Oil of turpentine spontaneously inflames in Cl. with a dull red light and a cloud of black smoke.

Turpentine consists of Carbon and Hydrogen. The Hydrogen combines with the Cl. and forms Chlorohydric acid, and the Carbon deposited constitutes the smoke.

Ill. 33. Pulverized Antimony spontaneously ignites when dropped into Cl. with a shower of fire and Chlorid of Antimony, Sb Cl_3 , is formed.

Ill. 34. Gold dissolved in a strong solution of Cl.

20. Cl. is a powerful bleacher. It destroys animal and vegetable coloring matters, by decomposing them and withdrawing the Hydrogen from them. It is the agent used in manufacturing processes, for bleaching linens and cottons, and colored rags, for making white paper.

Ill. 35. Indigo bleached by a solution of Cl.

Ill. 36. Ink formed from its elements, Oxyd of Iron, and Tannic acid; and bleached by Cl. The Tannic acid only, is decomposed, and when this is renewed the color is restored.

Ill. 37. Printed cottons bleached with Cl. water.

21. Solution of Cl. is to be kept in dark bottles and in a dark closet, since light renders the Cl. active, and capable of decomposing the water in which it is dissolved. This it does, by combining with its Hydrogen to form Chlorohydric acid, while Oxygen is liberated.

Cl. may then exist in two different states; an active and an

19. What is said of the affinities of Cl.? What are its compounds called? Describe the action of Cl. on Phosphorus in 31?

What is the composition and symbol of the Chlorid of Phosphorus formed? Action of Cl. on turpentine, 32? Cause of the smoke? Action of Cl. on Antimony, 33? How is Gold dissolved, 34?

20. Bleaching properties and uses of Cl.? Cause of its bleaching power? What is bleached in 35? What is the composition of ink, and how does Cl. bleach it, 36? What is bleached in 37?

21. How is solution of Cl. to be kept and why? How does Cl. decompose its solvent water, and what are the changes? In what different conditions may Cl. exist?

inactive state. The different conditions which the same substance may take are called *allotropic*.

Cl. is therefore an illustration of *allotropism*, or the capability of existing in different conditions in which unlike properties are manifested.

Other examples of allotropism are common. A remarkable one is seen in the various forms of Carbon, as hereafter noticed.

III. 38. A dark blue bottle of Cl. water.

III. 39. Solution of Cl. filling the flask, and in part, the bottle (fig. 12), set aside to decompose by exposure to light.

22. Cl. is a disinfectant, and is used on this account to advantage in hospitals and the chambers of the sick. It is an excellent purifier of the air in all rooms and inhabited places, being capable of decomposing all infectious matters, poisonous exhalations, and fetid odors; but it is to be employed with caution and not in sufficient quantity to produce coughing.

It will, in large quantities, cause inflammation, coughing, spasms, and death.

It is most conveniently obtained from the aqueous solution, for the purpose of purification, and also for removing fruit stains in white linens and cottons.

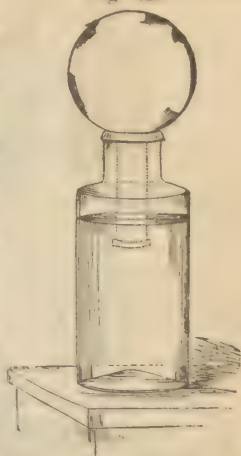
It may be obtained, for disinfecting purposes, from bleaching-powder (incorrectly called chlorid of lime), by putting in it a drop or two of Sulphuric acid (oil of vitriol).

III. 40. Cl. liberated from bleaching powder.

Cl. is used also medicinally in pulmonary diseases, in which case it is best inhaled from an exceedingly dilute aqueous solution, by drawing with the mouth at the tube in a simple apparatus, as in fig. 13, page 24.

III. 41. Inhalation of Cl.

Fig. 12.



Decomposition of Chlorine Water by Light.

What name is given to the different conditions of the same substance? What is allotropism? Commonness of allotropism? Example? What is III. 38? 39?

22. Why is Cl. used in hospitals? Where and why used to advantage as a purifier? What caution in the use of Cl.? Its effects in large quantity? Most convenient source of Cl.? Other source mentioned? How is Cl. liberated in 40? Medicinal use of Cl.? How administered (fig. 13), III. 41?

Fig. 13.



Inhalation of Chlorine.

23. Cl. is always present in blood, and generally in animal and vegetable bodies, in the state of common salt and other Chlorids.

The *test* for the presence of Cl., whether free or combined, is Nitrate of Silver, AgO , NO_3 , which by the Cl. is converted into insoluble Chlorid of Silver, AgCl .

Ill. 41, a. Solution of AgO , NO_3 , produces a white precipitate of AgCl , when dropped into Chlorine water.

The fourth simple substance, in order, according to the plan of this work, is—

FLUORINE, F. *Eq. 19. D. 1.272, Air 1.*

24. This substance is found in combination in slight quantities in sea-water, soils, plants, and animals. F., combined with Calcium,

constitutes Fluorid of Calcium, known as Derbyshire Spar, a moderately abundant mineral.

From its use as a flux, Derbyshire Spar is called also, Fluor Spar, whence the name *Fluorine*.

Ill. 42. Specimen of Fluorid of Calcium.

25. F., having powerful affinities, is isolated with great difficulty, and therefore seldom exhibited in the class-room.

It is a reddish brown gas, having something of the odor and properties of Cl.

Fluohydric acid, which consists of F. and Hydrogen, has the singular property of acting on glass. By this acid, etching on glass is performed.

Ill. 43. Specimen of an etching.

23. Presence and condition of Cl. in plants and animals? Test for Cl.? Result of the reaction between Cl. and AgO , NO_3 ? What is the fourth simple noticed? Symbol, equivalent, and density, of F.?

24. Where and in what state is F. found? Composition, name, and abundance, of Fluorid of Calcium? Origin of the name Fluorine? *Ill. 42?*

25. Isolation of F.? Properties of F.? What acid acts on glass? Use of Fluohydric acid? *Ill. 43?*

REVIEW OF IODINE, BROMINE, CHLORINE, AND FLUORINE.

26. These four simples are remarkable examples of *similarity among different substances*.

They alike have powerfully pungent odors, strongly resembling each other; and, unlike most other simples, are brightly colored, though varying in depth of color from I., which is deepest, to Cl., which is palest.

They are susceptible of a ready change in form, taking either the solid or the liquid, and also the aëriform state.

They are never found in nature uncombined. They are more abundant in the sea than elsewhere, owing to the easy solubility of most of their salts, by which means they are being constantly transported from the soil into the sea by rains and streams.

Their affinities are exerted at ordinary atmospheric temperatures: they enter into combination without the aid of heat; but this combination often gives rise spontaneously to such elevated temperatures as to produce the phenomena of fire.

They are universal in their affinities, combining among themselves, and generally with the other simples.

They alike decompose animal and vegetable substances, by their strong attraction for the Hydrogen which these substances contain. By the same means, they destroy animal and vegetable colors, and are active bleachers.

By combining severally with Hydrogen, they form the group of *Hydracids*; and these are excessively pungent, soluble in water, and resemble each other as much as the four simples themselves. Chlorohydric acid is the commonest representative of this class. They are noted for their action on metals, quickly corroding those which are affected by other substances with difficulty. Their affinities are singularly influenced by light, as seen in the decomposition by light of an aqueous solution of Cl., and exhibited, in respect to Br. and I., in the daguerreotype process.

They form, by combining with metals, the group of *Haloid salts*, or salts resembling sea-salt in composition.

26. Of what are I., Br., Cl., and F., remarkable examples? What of their odors? Of their colors? Change of form? Natural condition? Where most abundant and why? Affinities of I., Br., Cl., and F.? Necessity of heat to the exertion of their affinities? Effect of their combination? Their universal affinities? Action of I., Br., Cl., and F., on animals and vegetables, and their colors, and why? Composition of the Hydracids and their properties? Most common Hydracid? Action on metals? Influence of light on their affinities? Examples? Composition of Haloid salts? What are Haloid salts?

They have characteristic differences among themselves, however, as shown in the history of each already given, and seen in the study of their compounds, which will come up hereafter.

The different members of this group are so remarkably alike, that attempts to group other simples will, in contrast, seem but partially successful.

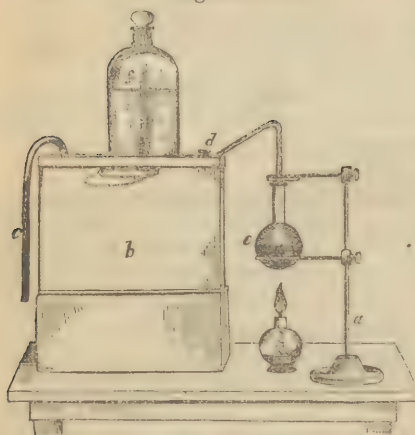
Oxygen, the simple substance next to be noticed, and the fifth in our course, slightly resembles the simples of this group in several particulars, but more especially in its enérgetic and universal affinities.

OXYGEN, O. *Eq. 8. D. 1.106; Air, 1.*

27. *Oxygen is the most abundant and important of all substances.* It exists in a free state in air, of which it forms more

than one fifth. Eight ninths of all water are O. It is the chief element of plants, animals, and minerals, and probably constitutes half of the earth.

Fig. 14.



Oxygen collected over Water.

28. Oxygen is most easily obtained from Chlorate of Potassa, KO, ClO_3 , by means of Binoxyd of Manganese, MnO_2 , and heat. In this process, while the Binoxyd is unaffected, all the O. in the KO, ClO_3 , being six equivalents, is expelled, thus converting this salt into Chlorid of Potassium, KCl .

Characteristic differences of I., Br., Cl., and F.? Success in grouping other simples? Fifth simple noticed? In what does O. resemble the members of the Iodine group? Symb., equiv., and deas., of O.?

27. Importance of O.? Where is O. naturally in a free state? What part of air is O.? Of water? Classes of bodies in which O. is found, and its abundance?

28. From what is O. obtained, and by what means? What is the symbol of Chlorate of Potassa? Of Binoxyd of Manganese? What change do the MnO_2 and the KO, ClO_3 respectively undergo in the process? Draw the symbols on the black-board, and explain their meaning and the changes?

For KO , $\text{ClO}_5 = \text{KCl}$. and O_6 . Here K. represents Potassium.

Ill. 44. O. procured by heating KO , ClO_5 , with $\frac{1}{2}$ its weight of MnO_2 , and collected over water (fig. 14), page 26.

Ill. 45. Collection of O. by displacing air (fig. 15), since it is heavier than air.

29. O. is a permanent gas, not having been liquefied by the pressure of 800 times that of the atmosphere, to which it has been subjected. It is soluble in 22 times its volume of water, and is colorless, tasteless, and inodorous. It is about $\frac{11}{10}$ as heavy as air, as seen by the figures at the head of the section, denoting its density.

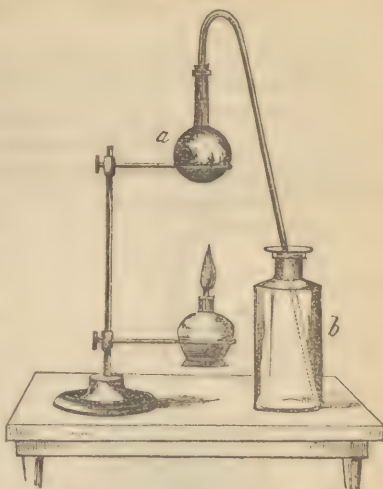
30. The affinities of O. are very powerful, and exerted in general more rapidly at high than at low temperatures. O. combines with all the simples but F. It forms Oxyds by combining, and also Oxacids and Oxyalts.

The burning of fires is maintained by the O. of the air. Nitrogen, the other chief element of air, has no action on burning. Air, therefore, supports burning less readily than pure Oxygen, because in air, the O. is diluted and weakened by Nitrogen.

Ill. 46. A candle or taper, having a spark of fire on the wick, instantly inflames in O., and burns brilliantly.

31. In the ordinary burning of wood, bituminous coal, oil, tallow, spermaceti, wax, etc., the Carbon, C., and Hydrogen, H., present in these substances, combine with O. from the atmo-

Fig. 15.



Oxygen collected under Air.

How is O. collected in fig. 14? In fig. 15?

29. Form and liquefiability of O? Solubility of O? Color, taste, and odor of O? Heaviness?

30. Affinities of O., and effect of temperature? With what simples does O. combine? What classes of compounds does O. form? How are fires maintained? What is the chief element of air besides O? What is the action of Nitrogen on burning? Why is burning more ready in pure O. than in air? What is done with a candle in Ill. 46?

31. What two combustible elements do bituminous coal, oil, wax, etc., contain?

sphere, the Carbon thus forming Carbonic acid, CO_2 , and the Hydrogen forming water, H_2O . The same results attend their combustion in pure O.

Ill. 47. By the condensation of watery vapor on a cold glass surrounding a flame, the formation of water in common burning is proved.

Ill. 48. By the chalky appearance given to clear Lime water, agitated with the gaseous products of burning, the formation of Carbonic acid is indicated, since chalk consists of Lime and Carbonic acid.

Ill. 49. Steel watch-spring burns rapidly in Oxygen, with splendid scintillations (fig. 16).

Fig. 16.



Steel burning in Oxygen.

In this case, Oxyd of Iron, Fe_2O_3 , and Carbonic acid, CO_2 , are formed, since the steel consists of Iron and Carbon.

Ill. 50. Phosphorus burned in O. An exceedingly intense light, produced by the incandescence of the Phosphoric acid, PO_5 , which is formed.

31.a This poisonous Phosphoric acid, like vinegar and other acids, imparts a sharp and sour taste to water. Hence O. is so named from the Greek *oxus*, sharp, and *gennao*, I produce; that is, O. is a generator of sour sub-

stances, for in many cases acids are formed by the burning of combustibles in O.

32. There are three things in which acids generally, though with some exceptions, agree: *firstly*, in being readily soluble in water; *secondly*, in having a sour taste; and, *thirdly*, in giving a red color to blue litmus-water, and to the purple color imparted to warm water by red cabbage, violets, purple dahlias, and similarly colored flowers.

In burning, what becomes of the C. and H. of the material burned? Is it the same with burning in pure O.? What are the symbols of water and of Carbonic acid? How is it shown, 47, that H_2O is formed, in burning? How, in 48, that CO_2 is formed? When steel burns in O., 49, what are the appearances, and what substances are formed? Of what is steel composed? Symbol of the Oxyd of Iron produced in 49? Describe the burning of Phosphorus, the substance formed, and its symbol? Is PO_5 harmless? Acids give what taste to water? Derivation of the word Oxygen, and why?

32. In what three things do acids agree?

Ill. 51. Infusion of litmus or cabbage, reddened by the soured water over which Phosphorus has been burned.

33. *In some cases the product of combustion is not acid*, as in the burning of the Iron of Steel, and of the Hydrogen of most materials consumed in common fires.

The compound of Hydrogen with O., known as Water, HO, like the Iron compound, Fe_2O_3 , is an Oxyd.

The term Oxyd is sometimes made to include the *Oxacids*, or mineral acids, like the Phosphoric, which contain O.; but by an Oxyd is more generally understood an Oxygen compound, which is not sour, and has no acid properties.

Many Oxyds, for example those of Hydrogen and Iron, have no action whatever on colors.

34. In other instances, the compound of a substance with O., though termed an Oxyd, turns the colors of red cabbage, etc. (but not that of litmus), to a lively green. Such Oxyds are powerfully caustic, and are known as *Alkalies*.

These alkalies, as well as many other Oxyds, neutralize acids, destroy their sour taste, and restore the blues and purples which acids have reddened.

The alkalies, and the other Oxyds which are capable of combining with acids to form salts, are called *bases*, and sometimes *salifiable bases*.

Ill. 52. Potassium burned in O. Potassa, KO, formed.

Ill. 53. The alkaline cloud of KO, formed in *Ill. 52*, on being agitated with red-cabbage water, turns it green.

Ill. 54. The blue of reddened litmus water restored by KO.

35. *Any gas destitute of odor, and having the characteristic action of O., on burning, can be no other than O.*

Ill. 55. Ignited pine or paper inflamed by a stream of O.

36. The heat from a fire is much increased in intensity by throwing in air, or, what is better, pure O.; since the chemical combination, the cause of the heat, thus becomes more rapid.

Ill. 56. A watch-spring, or slender steel wire, burned with beautiful scintillation in the flame of an alcohol lamp, into which a jet of O. is projected.

What reddens the litmus, etc., in 51?

33. Is the product of combustion always acid? Examples? What is an Oxyd? Do Oxyds act on colors?

34. Name and properties of the class of Oxyds that change vegetable colors to a green? Action of alkalies and some Oxyds on acids, and the colors that acids have changed? What are salifiable bases? What is formed in burning Potassium in O., 52? How is red-cabbage water, in 53, turned green? The blue of reddened litmus how restored, 54?

35. How is O. known? Effect of O. on ignited wood or paper, 55?

36. Effect of increased quantity of air or O. on the heat of fire, and why? Describe the watch-spring experiment, 56?

37. In all cases, there is a consumption of O, as well as of the combustile, in the process of burning.

If the operation of burning steel in O. is performed in a bell glass, closed at the top, and standing in water, the loss of O. is evident.

The withdrawal of O. from the atmosphere is seen to be very extensive, when it is considered that the perfect combustion of 600 lbs. of pure coal requires 1,600 lbs. of Oxygen. As 100 cubic inches of O. weigh 34.29 grains, a volume of nearly 20,000 cubic feet, or the Oxygen of 100,000 cubic feet of air (27), is abstracted in the burning of this quantity of coal. And if, in a grate, 25 lbs. of anthracite are burned in 24 hours, this will extract from the atmosphere in that time 763 cubic feet of O., equal to the O. of nearly 4,000 cubic feet of air.

Ill. 57. The flame of a lamp placed under a closed bell glass of air, standing in water, is soon extinguished, and the water rises by atmospheric pressure, all in consequence of the withdrawal of O. by the burning of the lamp.

38. *Respiration is a process which, chemically considered, is the same as combustion.* It is a slow burning, by which the moderate heat of animals is maintained.

Inhaled air, like that passed through a fire, has a portion of its O. withdrawn and converted into Carbonic acid, CO_2 , and water, HO , by a combination of O. with some of the Carbon and Hydrogen of the animal body.

Ill. 58. A cold glass quickly covered with the condensed vapor of water, when held in a current of air exhaled from the mouth and nostrils.

Ill. 59. Exhaled air, projected from the mouth through a tube into lime-water, converts the clear liquid to a turbid white, showing the formation of Carbonate of Lime, from the Carbonic acid of the breathed air.

Death follows in two or three minutes when respiration is totally suspended; and premature death is no less certain, though not so sudden, in all cases where the supply of air is permanently inadequate.

If it is considered that each inhalation of an adult takes, on the average, a pint of air, and that there are 20 inhalations a minute, it is seen that $2\frac{1}{2}$ gallons of air each minute pass through the lungs. As this, when exhaled, poisons ten times as much

37. In burning, what is consumed, besides the combustile? In what case is this proved? What weight of O. is required to burn 600 lbs. of coal? How much in bulk? State the ratio of O. to coal for a grate-fire? Describe and explain 57?

38. What is said of Respiration? What change does inhaled air suffer? Source of the moisture, 58? Of the Carbonic acid, 59? Consequences of an inadequate supply of air for respiration? Average amount of air inhaled at once? How many inhalations a minute?

more, *a barrel of air a minute* is not an unnecessary allowance for an adult.

A proper estimate of the quantity of air required by a million of people, will show that a daily supply of about two cubic miles of air is requisite. This indicates the transcendent importance, to life and health, of winds, ventilation, and of all agencies that tend to keep the air in motion, and to furnish a free supply of the life-giving element.

39. The O., the vital element of air, would therefore, notwithstanding the vast extent of the atmosphere, become exhausted in course of time, were there no compensating influence by which to maintain the balance.

The action of vegetation is the compensating agency by which O. is returned to the atmosphere. The watery vapor and the deadly poisonous Carbonic acid, into which breathing and burning convert O., are, by plants, assisted by the sun's rays, decomposed; so that, while their Carbon and Hydrogen go to build up the vegetable structure, O. is again thrown out into the air.

These opposing results seem so nicely adjusted as to be exactly equal; and O. is incessantly moving in this circuit, entering into combination through the influence of combustion and respiration, and then becoming liberated by the agency of the green leaf; and it is therefore constantly connected with the processes of both animal and vegetable life.

40. There are no substances intimately resembling Oxygen. Sulphur, the sixth non-metallic simple in our course, has perhaps, as strong similarities to it, as any other simple substance.

SULPHUR, S. Eq. 16. D. $\left\{ \begin{array}{l} 6.65, \text{ Air, 1.} \\ 1.98, \text{ Water, 1.} \end{array} \right.$

41. S. like O., is found both in a free state and in combination. It is thrown out by volcanoes, and is abundant in their vicinity.

How much air per minute does an adult require, and why? How much air do 1,000,000 people require? What does this indicate?

39. In what case would the O. of the atmosphere become exhausted? What restores O. constantly to the atmosphere, and how? Which produces the greatest effect in reference to absorption or liberation of O., breathing and burning, or the action of plants? In what circuit does O. move? With what is it connected?

40. What is said of the resemblances of other substances to O.? What simple substance has strong similarities to O.? What is the sixth simple noticed? Mention in order the five previously noticed? Symb., Equiv. and Dens. of Sulphur?

41. In what condition is S. found?

S. is an element of the *sulphurets*, in each of which it is combined, in general, with some simple substance. Sulphuret of Iron, consisting of S. and Iron, is one of the commonest minerals; and the Sulphurets of Lead, Copper, and Zinc, are very abundant.

S. combined with O_3 , forms Sulphuric acid, which united with bases constitutes the *Sulphates*.

Sulphate of Lime, consisting of SO_3 , and Lime, CaO is the most abundant Sulphate.

S., besides, exists to a moderate extent in plants and animals.

42. *Native S.*, or S. in the natural, uncombined condition, is generally mingled with various earthy impurities, from which it is separated by fusing it, and running it into moulds, thus forming the *roll sulphur*, or *brimstone* of commerce. Also, it is purified by vaporization, the vapor being condensed into a crystalline powder, known as *flowers of Sulphur*.

When a solid is vaporized, and the vapor solidified, the process is called *sublimation*, and the sublimated substance a *sublimate*.

III. 60. Specimens of S., in roll and in flowers; also of Sulphuret of Lead and Sulphate of Lime, (gypsum).

43. S. is generally solid, but fuses at 226° and begins to evaporate below that temperature. It boils at 600° . It is insoluble in water, but may be dissolved in Bisulphuret of Carbon.

Its color when crystalline is yellow, but is white when it is precipitated. S. is tasteless; it gives the S. odor when warm. In the solid state it is nearly twice as heavy as water, as seen by the figures at the head of the section.

S. is generally very brittle, but may be converted to a soft impressible condition, by fusing it, raising the temperature to about 500° , and then plunging it into cold water. It remains in this soft state for many hours. In this case, though perfectly fluid at 226° , it grows thicker as the temperature increases.

III. 61. S. converted to the soft condition.

44. S. is an example of a *dimorphous* substance. By this is meant that it crystallizes in two distinct forms, having no

With what is S. combined in a Sulphuret? Explain the composition of the Sulphates? Most abundant Sulphate? Where does S. exist in the compound state besides in Sulphurets and Sulphates?

42. What two processes for the purification of S.? What is roll brimstone? Flowers of S.? What is sublimation? A sublimate?

43. Form, fusibility, boiling point, and solubility of S.? Color, taste, odor, and heaviness of S.? Brittleness? How rendered soft? Effect of raising its temperature beyond 226° ?

44. What substance is dimorphous? Meaning of dimorphous?

relation to each other. These two forms are, in case of S., the *right rhombic octahedron* (fig. 17), and the *oblique rhombic prism*.

Ill. 61. α . Models of the right rhombic octahedron, and oblique rhombic prism.

Ill. 62. S. being fused is allowed to cool until a crust forms upon its surface. Carefully breaking this crust, and pouring out the remaining liquid, slender prismatic crystals, belonging to the second form of S., are seen crossing each other in all directions, as in fig. 18.

45. S. has powerful affinities. Heated with access of air to about 300° , it takes fire, and, as it burns, with a purple flame, forms Sulphurous acid, SO_2 .

SO_2 has bleaching, as well as acid properties, and is used in bleaching straw goods. It is SO_2 which gives the powerfully pungent odor noticed whenever S. is burned.

Ill. 63. Lighted S. burns in O., with a pale purple flame, the SO_2 formed produces a cloud by condensing the vapor of water present, with which it unites; and this cloud is absorbed by liquid water in the bottle in which the operation is performed.

Ill. 64. The solution of SO_2 reddens and bleaches litmus water.

Ill. 65. Two or three grains of S. rubbed with Chlorate of Potassa detonate violently; the S. taking O. from the Chlorate, and forming SO_2 .

46. On account of its ready combustibility, S. is extensively used in making matches and gunpowder. More S. is consumed in the manufacture of Sulphuric acid, than for any other purpose. S. and its compounds are much used in medicine.

The seventh and eighth non-metallic simples are

SELENIUM, Se. Eq. 40. D. 4.3, Water, 1, and

TELLURIUM, Te. Eq. 64. D. 6.26, Water, 1.

47. These two substances are very rare in nature. So far as is known they are of little importance or use. They have

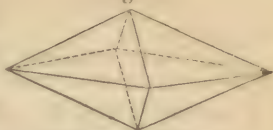
In what forms does S. crystallize? Give the name of each model, 61? How is S. crystallized in 62?

45. Affinities of S.? Examples? Effect of heating S. to 300° ? The product of the burning of S. and its symbol? Properties and use of SO_2 ? Cause of the pungent smell when S. burns? Describe the burning of S. in O., 63? Effect of SO_2 on litmus, 64? Detonation produced, 65, and why?

46. Uses of S., and why? Chief consumption of S.? Medicinal uses of S.? What are the seventh and eighth simples noticed and their symbols? Repeat, in order, the names and symbols of the first eight simples?

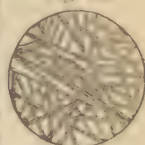
47. What is said of Se. and Te.?

Fig. 17.



Rhombic Octahedron.

Fig. 18.



Slender Prismatic Crystals of Sulphur.

strong resemblances to S., and like it are readily combustible.

They have sometimes been included among the metals, but are deficient in capacity to conduct heat and electricity.

Ill. 66. Specimens of Se. and Te.

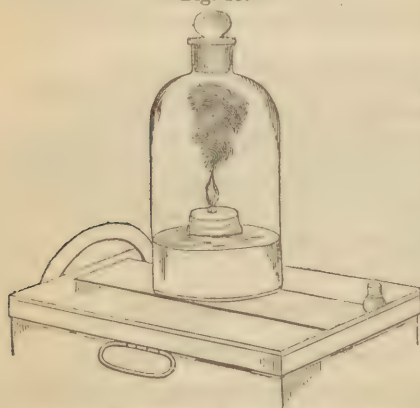
The ninth simple is

NITROGEN, N. *Eq. 14. D. .97, Air, 1.*

48. N. is one of the more abundant and important simples. It exists in a free state in air, and in combination, in animal, and in some vegetable and mineral substances. Since it combines, by various natural influences, with O. and Potassium, and forms Nitrate of Potassa (*nitre*), it is called *Nitrogen*, a producer of *nitre*.

From an incorrect notion that it is poisonous, it has also been called *azote*, i. e., *life destroyer*.

Fig. 19.



A residue of N., when Phosphorus is burned in confined Air.

49. N. is most easily obtained by burning Phosphorus in confined air. By this means the O. of the air is converted into compounds containing Phosphorus, which are readily absorbed by water.

Ill. 67. Phosphorus burned in a bell-glass (*fig. 19*), over water, and the cloud formed, washed from the N., by pouring the mixture into a bottle and agitating with water.

Ill. 67, a. By taking a glass tube of uniform bore, closing one end, fixing a piece of Phosphorus within, near the closed end, and pla-

cing the tube erect, with the open end in water, the Phosphorus withdraws all O. from the confined air, the water absorbs the compound formed, and in

Their metallic properties? *Ill. 66?* Give the name, symbol, equiv. and density of the ninth simple? Repeat the names and symbols of the first nine simple substances, in the order in which they have been noticed?

48. Abundance and importance of N.? Where is it free and where in combination? Why so called? Why called azote?

49. Easiest process for obtaining N.? Describe the process, *67?* How is it indicated, *67, a*, that one fifth in bulk of the atmosphere is O.?

a day or two, when the process is complete, the water rises one fifth of the length of the tube, indicating that one fifth in bulk of the air is Oxygen.

50. N. is a permanent gas, never having been liquefied. It is slightly soluble in water; colorless, tasteless, and inodorous, and is nearly as heavy as air.

51. N. is remarkable for its weak affinities. It does not combine directly with any of the simples. By indirect means it forms, however, numerous compounds; but they are readily decomposed.

Ill. 68. N. and O. contrasted in their action on burning. A taper repeatedly extinguished in N., but relighted in O.

52. N. is an unvarying element in flesh, or lean meat; and, also, in all truly nutritious or flesh-forming food. Sugar, Starch, Gum, arrowroot, and such other substances as contain no N., though having their uses, as noticed hereafter, are therefore not really nutritious, being incapable of forming flesh, and of preventing the waste of muscle inseparable from animal motion.

N. is contained in the seeds of grain, as in wheat, rye, oats, barley, rice, and Indian corn; and forms in these, as well as in meat and milk, the really nutritious elements of food.

N. seems to be always present in the substances from which both animal and vegetable tissues are originally constructed, and has therefore most important relations to all material life.

The tenth simple is:—

PHOSPHORUS, P. *Eq.* 32. D. $\left\{ \begin{array}{l} 1.86, \text{Water, 1.} \\ 4.22, \text{Air, 1.} \end{array} \right.$

53. P. is a moderately abundant, though widely diffused, simple. It exists always in a STATE of combination, as in the *Phosphates*, the *Phosphurets*, and also in animal and vegetable bodies.

In a *Phosphuret*, P. is combined with some other simple. A *Phosphate* consists of *Phosphoric acid*, PO_3 , combined with some base.

50. Physical properties of N.?

51. For what is N. remarkable? What is said of its combination, and the compounds which it forms? Describe the contrast between N. and O., 68?

52. Of what is N. an unvarying element? What food is nutritious? What is said of sugar, starch, &c., as articles of food? What substances contain N. in a nutritious shape? Relations of N. to material life? Name, symbol, equivalent, and density of the tenth simple? Give the names and symbols of the ten in order?

53. Abundance of P.? State? Substances containing P.? A *Phosphuret*? A *Phosphate*?

54. Phosphorus exists most abundantly in the shape of Phosphate of Lime, which is an element of fertile soils, and also forms a large portion of the mineral known as *apatite*.

By a chemical process, Phosphorus is extracted from bones in which it exists as Phosphate of Lime.

55. P. is a solid, fusing at 111° , and boiling at 554° . It is insoluble in water, but dissolves readily in oils. When fresh it is nearly colorless, but takes a variety of colors.

It is tasteless. Its odor can never be known, owing to the change which air effects in it.

Ill. 69. Specimen of P. moulded into the usual cylindrical sticks.

Ill. 70. P. fused under hot water.

Ill. 71. P. dissolved in warm olive oil.

56. The tendency of P. to enter into combination with other simples is generally strong. Its attraction for O. is particularly energetic, and is exerted at all known temperatures.

Ill. 72. P. burned in O. An intense light produced. Phosphoric acid PO_5 formed.

Ill. 73. A small piece of dry P. wrapped in paper and rubbed takes fire.

Ill. 74. The P. fused under hot water burns there, when a stream of O. is forced upon it.

Ill. 75. A grain or two of Phosphorus, being struck, when lying among Chlorate of Potassa, explodes violently, since the P. taking O. from the Chlorate, suddenly forms a large quantity of vapor, and thus produces a concussion of the air.

Whenever exposed to the air, P. is continually combining with O.; and this chemical combination is attended by a development of light, which, though too faint to be noticed in full daylight, is very remarkable in the dark.

Ill. 76. P. shines in the dark.

Ill. 77. The solution of P. in oil shines, when the bottle containing it is opened.

57. Although there is some heat produced when P. is exposed to air, it is less noticeable than the light.

54. Most abundant Phosphate, and where found? P. is extracted from what?

55. Form, fusing, and boiling points, and solubility of P.? Its color, taste, and odor? Common shape of P., 69? How fused, 70? Dissolved, 71?

56. Affinities of P.? Its attraction for O.? Describe the burning of P. in O. 72, and name the product and its symbol? Effect of friction on P., 73? How is P. burned under water, 74? Exploded, 75, and why? Effect of the exposure of P. to air? Describe 76 and 77?

57. Amount of heat as compared with the light resulting from the action of air on P.?

The property of shining at temperatures below a red heat, known as *Phosphorescence*, is not peculiar to P., but is possessed by many substances. P., however, hence derives its name from the Greek of *phos* and *phero*, signifying, I give light.

58. To prevent the action of air, P. is generally kept wholly immersed in water. From its liability to take fire by the warmth of the hand, it can be safely handled only by keeping it constantly cold and moist.

59. Considerable quantities of P. are consumed in making matches; the mixture of P., on the match, ignites by the heat consequent on rubbing it.

60. P. is an indispensable element of animal food, from which bones and flesh must derive their P. It exists in bread, milk, beans, and peas, partly in the form of Phosphate.

No soil can be fertile which does not contain P. It may be supplied to soils by the application of bones, guano, animal manures, or an artificial Phosphate of Lime, known as Superphosphate. Every crop taken from a soil diminishes, to some extent, the quantity of P. present, and grazing has the same effect.

61. The three simples, Carbon, Silicon, and Boron, the history of which is next to be given, have among themselves some strong points of resemblance.

The eleventh simple is:—

CARBON, C. Eq. 6. D. $\left\{ \begin{array}{l} \text{Diamond, 3.5} \\ \text{Graphite, 2.2} \\ \text{Anthracite, 1.7} \end{array} \right\} \text{Water, 1.}$

62. C. is one of the more abundant elements. The *diamond*, the most valuable gem, and the hardest of all substances, is pure *crystallized* C. *Graphite*, known also as *plumbago* and *black lead*, is essentially pure C., as whatever other substances it may contain, are not chemical elements, but mechanical impurities.

The same is true of *anthracite coal*, and of *wood charcoal*.

Phosphorescence? Is it peculiar to P.? Origin of the name of P.?

58. How is P. generally preserved, and why? Caution in handling P.?

59. Use of P., and why?

60. Of what is P. an indispensable element, and why? In what condition does P. exist in bread, milk, &c.? Why is P. present in soils? How artificially supplied to them? How is P. exhausted from a soil?

61. Mention two simples having strong resemblances to Carbon? The eleventh simple noticed; its symbol and equivalent? Mention the names and symbols of the first eleven simples? [Give the respective densities of Diamond, Graphite, and Anthracite?]

62. Abundance of C.? What is said of diamond? Graphite? Anthracite and wood charcoal?

63. Bituminous coals, such as those of western Pennsylvania, Maryland, and Virginia, and the English and Nova Scotia coals, are distinguished from anthracite, by readily lighting and burning with flame and smoke, on account of the bitumen which they contain.

Mineral coal is undoubtedly of vegetable origin, being the remains of vast forests of luxurious growth, which, probably abounded on the earth before the creation of man, and which by various chemical and physical agencies, have been deposited and brought to the present condition, constituting a sufficient supply for the wants of the world for thousands of years to come.

Ill. 78. Specimens of Lehigh and other anthracite coals.

Ill. 79. Specimen of graphite.

Ill. 80. The ready combustibility of Cumberland and other bituminous coals, small pieces of which are lighted in the flame of a lamp. This can not be done with anthracite.

64. C. is an element of animal and vegetable substances of which it forms more than $\frac{1}{3}$ after they are completely dried. It also constitutes $\frac{2}{3}$ of Carbonic acid gas.

Although Carbonic acid forms less than $\frac{1}{1000}$ of the air, taken as a whole, there are millions of tons of C., in the atmosphere in this invisible gas.

Carbonic acid also exists in the Carbonates, in which it is combined with various bases. Carbonate of Lime, the most common Carbonate, constitutes the limestones, marbles, and chalk, and abounds in shells, corals, and bones. C. also exists in combination with H., in natural gases, and in peat, lignite, and asphaltum.

Ill. 81. Specimens of limestones, coral, marbles, shells, &c.

65. C. in the usual form, as in diamond, anthracite, and graphite is solid. It can be fused and even vaporized, though only by the most extreme heat known, produced by the most powerful galvanic battery. It is colorless, and of various tints in diamonds.

The properties of C., in its varying forms are quite different. Diamond and some coals are extremely hard, while graphite is soft, so that pencil points, for marking on paper, are made

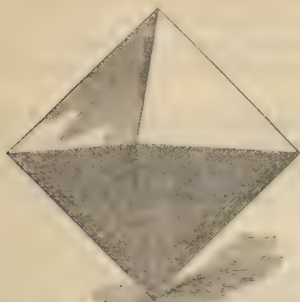
63. How are bituminous coals distinguished from anthracite? Localities of bituminous coal? [What is said of the origin of mineral coal? Of its abundance?] How is the ready combustibility of bituminous coal shown, 80?

64. Of what does C. form more than $\frac{1}{3}$? C. is $\frac{2}{3}$ of what substance? Quantity of coal in the air, and in what form? In what class of substances does Carbonic acid exist? Which is the most abundant Carbonate, and where is it found? In what natural substances does C. exist combined with H.?

65. Form and fusibility of C.? By what means fused, &c.? Color? State the differences in properties in diamond, graphite, and coals?

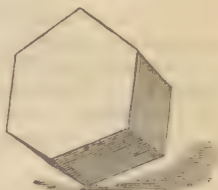
almost exclusively of it. Graphite is only burned with extreme difficulty, while anthracite is more readily combustible.

Fig. 20.



Regular Octahedron.

Fig. 21.



Hexagonal prism.

Diamond Crystallizes (Art.

3), in *regular octahedrons* (fig.

20), and allied forms; graphite in *hexagonal prisms* (fig. 21).^{*} Diamonds are transparent, while all other forms of C. are opaque. Diamond, anthracite, and graphite, therefore, are three *allotropic* states, or distinctly different conditions of C.

III. 82. Models of the regular octahedron, and of the hexagonal prism.

66. The affinities of C. are numerous and energetic; when acting artificially, the C. being nearly pure, they are exerted only at high temperatures.

In respiration, fermentation, and the decay of animal and vegetable substances, C. combines, however, with O. at moderate temperatures, forming Carbonic acid.

Intense heat and light are produced by burning coal, and substances rich in C., as seen especially in blast furnaces, and other contrivances, in which the fire is supplied with a profusion of hot air.

Fig. 22.



III. 83. Charcoal burned in O., (fig. 22,) with thousands of brilliant scintillations.

Charcoal burning in Oxygen.

^{*} The hexagonal prism is a solid having six sides, besides its bases, or ends, and is of equal bigness from end to end.

What is meant by saying that diamond, graphite, and anthracite, are *allotropic* states of the same substance? Describe the Regular Octahedron and the hexagonal prism?

66. Affinities of C.? In what processes does C. combine with O., at moderate temperatures, and what is the product? Describe the burning of Charcoal in O., 83?

Carbonic acid, CO_2 , is formed whenever coal, graphite, or diamond, is burned in air or in O .

67. The preparation of animal and vegetable charcoal by heating or burning wood and bones in close places, with a very limited supply of air, depends on the fact, that the C. which these substances contain, is less volatile and combustible than their Hydrogen, so that the latter is driven off or consumed, while the former remains.

68. C. serves a great variety of important natural and artificial purposes. Substances consisting either wholly or partially of C. are consumed to produce heat and light. Charcoal is one of the elements of gunpowder. Diamonds are employed to cut glass.

Charcoal, being exceedingly porous, is capable of largely absorbing gases and coloring matters. On this account fetid water is rendered sweet, by filtration through wood charcoal, and the colored syrups of brown sugars are whitened by means of animal charcoal.

Ill. 84. Litmus bleached by filtration through animal charcoal.

69. C. is largely an element of all kinds of food. It is also the chief ingredient of that portion of soils which has been formed by the decay of plants. It is in such soils as have a large share of this vegetable mould that the most luxuriant growth of plants is seen.

70. The simple substances having the strongest analogy to Carbon are Silicon and Boron. The twelfth simple is

SILICON, Si. *Equivalent, 21.3*

71. Silicon, after O., is the most abundant substance in nature. It exists only in a state of combination, chiefly in the form of Silicic acid, SiO_2 , which consists of Si. and O.

SiO_2 is nearly pure in different kinds of quartz rock, rock crystal, flint, and sand.

Is the product of the combustion of the different forms of C. the same.

67. On what principle does the preparation of charcoal depend?

68. Mention uses of the various forms of C.? How is it that fetid water is sweetened, and sugar syrup is bleached, by filtration through charcoal? Litmus water bleached, 84?

69. What is said of C. in food and in soils?

70. What simples are most similar to C.? Name, symbol, and equivalent of the twelfth simple? Give the names and symbols of the first twelve simples in order?

71. Abundance of Si.? Natural state? Composition and symbol of Silicic acid? Where is SiO_2 found nearly pure?

It takes its name from *siler*, flint, whence the name of Si. is derived.

SiO_2 forms a large share of *granite* and *syenite*. Silicates, or such compounds of Silicic acid with bases, as *serpentine*, *talc*, and *feldspar*, are also abundant.

Ill. 85. Specimens of rock crystal and quartz.

Ill. 86. Specimens of talc, serpentine, and feldspar.

72. Si., which is isolated by a somewhat difficult process, is, when pure, a brownish solid, insoluble and infusible, but combustible in air, burning and combining with O. to form SiO_2 .

73. As a simple, Si. is of very little importance, but in the compound state, as SiO_2 , it is an important element of glass and of plants. It is found especially in the stalks of grain and the grasses to which it aids to give inflexibility. This, and its great abundance as a mineral element, place it among the most important simple substances. The thirteenth non-metallic simple is—

BORON, B. *Equivalent*, 10.9

74. This substance exists in *borax*, from which its name is derived, also in Boracic acid BO_3 . Borax is a Biborate of Soda, consisting of BO_3 and Soda, and is found in the waters of several lakes of Thibet.

Boracic acid abounds in the volcanic vapors of Tuscany and the Lipari islands, from which it is extracted for the manufacture of borax.

Ill. 87. Specimens of Boracic acid and borax.

75. Boron closely resembles Si., in its physical and chemical properties. It is not very abundant as compared with O., Si., etc., and is of no importance in the simple state. The fourteenth and last non-metallic simple is

HYDROGEN, H. *Eq.* 1. *Density* .0692, *Air*, 1.

76. H. is one of the more abundant elements, constituting a

What two rocks are mentioned as containing SiO_2 ? Composition, names, and abundance of Silicates?

72. Isolation and properties of Si.?

73. Importance of Si. as a simple? In the compound state, and why? Name, symbol, and equivalent of the thirteenth simple? Names and symbols of the first thirteen simples in order?

74. Natural conditions of B., and origin of its name? Sources and uses of Boracic acid?

75. Properties, abundance and importance of B.? Name, symb., equiv. and density of the fourteenth simple? Give, in order, the names and symbols of the fourteen non-metallic simple substances?

76. Abundance of H.?

portion of animal and vegetable substances, and existing in many minerals. It is found only in a state of combination.

77. H. is always obtained from water, of which it forms $\frac{1}{9}$ part.

There are several methods of obtaining H. from water, as by the action of electricity, by means of a metal alone, or by the action of a metal assisted by heat, or an acid.

Ill. 88. Water decomposed by the galvanic battery; its elements, Oxygen and Hydrogen obtained separately. Mixed and fired they reunite with a detonation and form water.

Ill. 89. Potassium introduced into an inverted glass of water, over the pneumatic trough, liberates H., by withdrawing and combining with O. to form Potassa.

Ill. 90. The H. inflamed.

Ill. 91. Chips of Iron, in water containing one tenth in volume, of Sulphuric acid, SO_3 ,* liberate H. with effervescence, and the formation of Sulphate of Iron, FeO, SO_3 .

Ill. 92. Zinc, Zn. acts in the same manner, taking as Iron does, O. from the water HO ., to form an Oxyd, ZnO , with which the sulphuric acid, SO_3 , unites and produces Sulphate of Zinc, ZnO, SO_3 .†

77, *a.* The materials for the liberation of H. are usually placed in a glass flask, but when considerable quantities of the gas are required, a cylindrical copper *evolver*, *f*, fig. 23, having a second cylinder inside of half the height, may be used.

The inside cylinder at the bottom contains a basin pierced with holes like a colander. This basin supports the zinc. The top of the inside cylinder

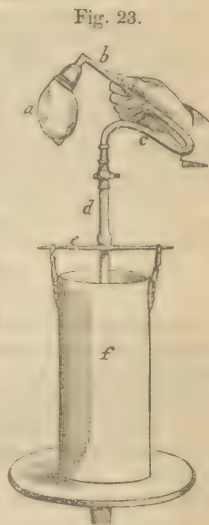


Fig. 23.

* The Sulphuric acid used is HO, SO_3 ; but the presence of the water, HO may for the present be overlooked.

† The chemical changes in these, and in all other cases, may be represented by a diagram on the black board similar, in plan, to that used, fig. 9, to explain the changes in obtaining Cl.

By this means greater simplicity and interest will be given to a part of the subject with which the learner should be perfectly familiar.

Where is H. found, and in what state?

77. From what is H. obtained? What part of water is H.? Mention the several methods for obtaining H. from water? Describe the decomposition of water by the galvanic battery, and 88, in full? What metal is used alone in 89, to decompose HO ., and what is the result? What is done with the H. in 90? How by means of a metal, assisted by an acid, is H. obtained, in 91? What substance is formed, how is it formed, and what is its symbol? Mention the changes, the products, and their symbols, in the action of Zinc on the water and acid, 92?

[77, *a.* What is generally used to contain the materials for the liberation of H.? Describe the copper H. *evolver*, fig. 23, and the particulars in reference to its use?]

opens through the erect copper tube (*d*), having a stop-cock to which a flexible tube (*e*), is attached.

This inside cylinder is, when necessary, prevented from rising by the horizontal brace (*c*) and thumb-screw. All things being in place the mixture of water and acid is poured in, and when the stop-cock is opened the air within the inner cylinder escapes, as the liquid sinks in the outer cylinder and rises in contact with the Zn. within. A continued stream of H. is furnished until the materials are exhausted; though the process may be arrested at any time by closing the stop-cock.

The figure represents the blowing of Hydrogen soap bubbles. The gas may be passed into a balloon or collected in vessels by displacement of either air or water, from this *evolver*.

The process for obtaining H. by means of a metal and heat, consists in passing steam through a red hot iron tube, containing chips of iron. The Iron retains the O. to form Oxide of Iron Fe_2O_3 , while the H. is liberated.

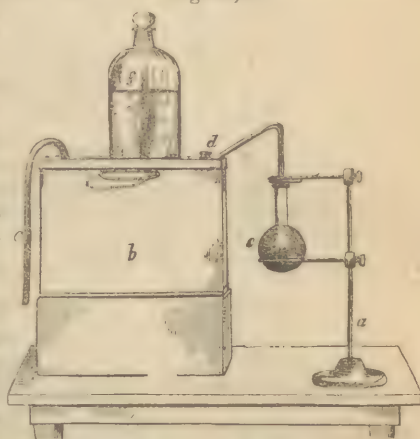
Ill. 93. H. collected over water, as in fig. 23, a. No lamp heat is required to assist the evolving process.

78. H. is a permanent gas, having been subjected like O. and N. to a pressure of 800 atmospheres without liquefaction. When pure, H. is colorless, tasteless, inodorous, and very slightly soluble in water.

H. is the lightest known substance; its specific gravity being only .0692, or more than 14 times less than that of air. Nearly 100 gallons of H., wine measure, are required to weigh a Troy ounce. One pound of H., *i. e.*, the H. of nine pounds of water, when liberated, measures 1412 wine gallons, and a gallon of water contains more than 1300 gallons (more nearly 1306.88) of H.

Ill. 94. Soap bubbles filled with H. rapidly ascend. Lighted they burn with a silent flash.

Fig. 23, a.



Hydrogen collected over Water.

[In what way is H. extracted by means of a metal and heat?]

How is H. collected in 93?

78. To what pressure have O. N. and H. been subjected without liquefaction? Color, taste, odor, and solubility of H.? Its lightness and sp. gr.? How much in volume of H. is required to weigh a Troy ounce? Bulk of a pound of H.? How many gallons of H. in one gallon of water? Properties of H. soap-bubbles, 94?

Ill. 95. A small balloon, made of pieces of thin animal membrane pasted together, when filled with H. is sufficiently buoyant, if as much as 12 inches in diameter, to rise, and in addition to lift a light weight, as a cork.

Ill. 96. H. being lighter than air, is collected over air, *i. e.*, by the displacement of air, passing it into an inverted bottle as in fig. 24.



Hydrogen collected
by displacement of
Air.

Fig. 25.



Arrangement to exhibit
the Diffusive Power of
Hydrogen.

79. The tendency of gases to mingle with each other, to spread themselves out into space, and to pass through minute orifices and pores, known as the *diffusive tendency*, or *diffusive power*, is possessed by H. to a greater degree than by any other substance.

Ill. 97. H. passes rapidly through the interstices of a porous galvanic battery cup, so as alternately to produce a condensation and a vacuum, when the cup is repeatedly immersed in a bell glass of H. as shown by closing the cup with a cork, inverting it, and passing an open tube through the cork down into a bottle of colored water (fig. 25). Firstly, as the bell of H. is held over the cup, the gas passes down through the tube and the bubbles rise through the water, and then, when the bell is slowly lifted, the colored water rises in the tube.

Describe the small balloon, 95? How and why may H. be collected by displacing air?

79. What is meant by the *diffusive tendency* of gases? Diffusive power of H.? Describe the process for illustrating the diffusion of H., 97?

80. The affinities of H. are extensive and energetic. With access of air it may be lighted and burns by combining with O. and forming water, whence its name from the Greek, *hudos*, water, and *gennao*, I generate. When pure, it burns slowly and silently, but mixed with $\frac{1}{2}$ its volume of O., or several times its volume of air, it explodes, when lighted, with great force, in consequence of the sudden expansion of the steam formed by the combination.

Ill. 98. A large inverted bottle of H. burned silently and slowly, the flame being only around the mouth.

Ill. 99. A lighted taper extinguished when immersed in the inverted bottle of H.

Ill. 100. The H. in the bottle, when erect, burns rapidly, and the flame enters the bottle.

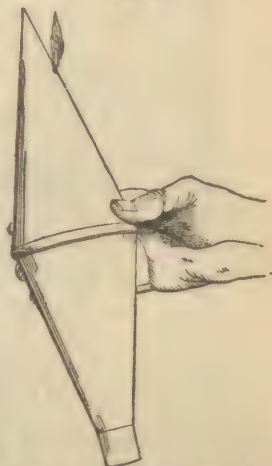
Ill. 101. The H. lighted at the top of a bell-glass, as the glass is raised from the cistern, burns with a double explosion, since there are two successive mixtures of H. and air.

Ill. 102. A louder explosion finally ensues when the mixture is formed more slowly in an open metallic double cone gas pistol (fig. 26). The H. is lighted at a small orifice toward the top, and burns for some time silently; then begins a humming sound, which grows more intense until the explosion occurs.

Ill. 103. Soap bubbles of mixed O. and H., there being two volumes of H. to one of O., explode violently when fired.

Ill. 104. The vapor of water, formed by the burning of H., condenses on a cold dry bell-glass, held over a Hydrogen flame.

Ill. 105. A gas-pistol being filled with the mixture of O. and H., a violent explosion instantly follows the application of a flame.



Hydrogen mingling with air in the Gas-Pistol, before exploding.

81. The flame of burning H. possesses so little light, as to be invisible in sunshine, owing to the fact that it is purely *incandescent** gas.

* Incandescence is the property of being luminous at high temperatures.

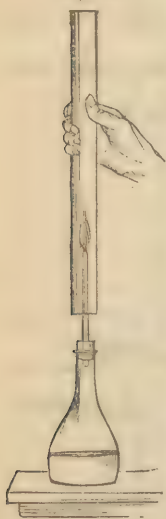
80. Affinities of H.? Why is H. so called? How does pure H. burn? How, when mixed with air or O.? Describe the burning of H. in the inverted bottle, 98? A lighted taper in H. 99? The burning of H. in an erect bottle, 100? By lighting the H. at the top of a bell glass, 101? Its burning in the double cone-pistol, 102? Hydro-Oxygen soap-bubbles, 103? How prove that water is formed by the burning of H., 104? H. pistol, 105?

81. Light of H. flame, and why?

At the same temperature, a solid body is much more highly luminous than a body of gas, such as constitutes the flame when H_2 burns, and as forms the larger share of flame in all cases.

The flame of a candle, or of a gas-light, shines chiefly on account of the solid particles of Carbon in it. These particles are derived from the Carburetted Hydrogen gas which is the principal element in such flames.

Fig. 27.



Musical Tones.

This gas consists of Carbon and Hydrogen. The H_2 being more readily combustible, burns first, and the C thus set free in fine particles, thickly floating in the flame, they are heated so as to give it nearly the brightness of a mass of solid Carbon of the same temperature.

Ill. 106. The faint appearance of the H_2 flame.

Ill. 107. Platinum held in the flame, is much more luminous, though the solid can be no hotter than the flame.

Ill. 108. A piece of glass in the flame of H_2 is not soiled by a black deposit of Carbon.

Ill. 109. A gas-light, or common lamp or candle-flame, quickly blackens the glass held in the flame.

82. By holding glass tubes of different sizes over the jet of burning H_2 , as in fig. 27, musical tones of various pitch may be produced. These arise from the detonations connected with the rapid succession of the blowing out, and re-lighting of the flame. The draft of air through the tube extinguishes the flame, which is re-lighted by the hot jet-pipe.

Similar sounds are sometimes noticed in connection with the burning of a Camphene lamp.

Ill. 110. Musical sounds of H_2 .

83. When a jet of H_2 blows upon a Platinum sponge, which is a highly porous mass of fine particles of pure Platinum, the sponge becomes so hot as to set fire to the jet. A suitable mixture of H_2 and O_2 , or H_2 and air, explodes on the introduction of the sponge.

This is owing to the fact that a large volume of H_2 , as well as

Comparative luminosity of solids and of gases at the same temperature? The flame of a candle or gas-light, why luminous? Explain the constitution of illuminating flame? What is shown, 106, of the H_2 flame? Platinum, 107? Glass in H_2 flame, 108? In gas-light, 109?

82. Musical tones, how produced, and why? *Ill. 110?*

83. What is Platinum sponge? Result of projecting H_2 upon it? Cause?

of air, is attracted and condensed in the pores of the sponge into a very small space; this condensation causes chemical combination with so much heat as to make the sponge glow and fire the H.

Sometimes a self-regulating H. jar (fig. 28), containing Water, Zinc, and Sulphuric acid, capable of producing H. at any time, and having a Platinum sponge attached, is placed upon a shelf and used instead of matches. It is only necessary to let out the H. for an instant, in order to get a light. The apparatus is, on the whole, as economical as common matches. Since Professor Dobereiner, of Jena, in 1824, was the first to notice this property of the sponge, the apparatus may be called a Dobereiner Jar.

The sponge is easily made by dissolving Platinum in Nitro-muriatic acid, precipitating with sal-ammoniac, and heating a mass of the yellow precipitate* supported on a net-work of Platinum wire, to a bright red heat.

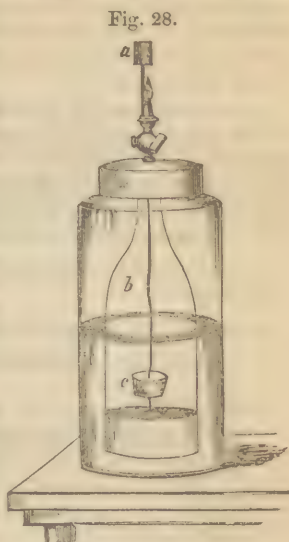


Fig. 28.

Dobereiner Jar.

Ill. 111. Platinum sponge made.

Ill. 112. A jet of H. lighted by means of the sponge.

84. Notwithstanding that the flame of burning Hydrogen is extremely faint in regard to light, its temperature is very high, and it may be made the hottest of all fires. This is due to the large quantity of O. required to burn Hydrogen.

Ill. 113. A flask of water boiled by means of the H. flame.

It is held to be theoretically true that in all fire, no matter what the combustible, where equal quantities of O. are consumed, there are equal quantities of heat produced; and that

* This precipitate is the double Chlorid of Ammonium and Platinum, NH_4Cl , Pt. Cl_2 .

Who discovered the action of Pt. sponge, and when? Describe the Dobereiner jar? How may a Pt. sponge for this purpose be made? How is H. lighted, 112?

84. Heat of the H. flame, and why? How is water boiled in 113? What is the theory in respect to the quantity of heat from combustion?

the amount of heat is always in proportion to the consumption of O.

In this respect, theory and experiment agree. For example, a given weight of H. is capable of combining with three times as much O., as the same weight of C., and therefore a pound of H. in burning should produce three times as much heat as a pound of charcoal.

By experiment, it has been found that while a pound of charcoal, when burned, will produce heat sufficient to raise the temperature of 78 pounds of water from the freezing to the boiling point, a pound of H. will, by its burning, give heat to bring 236 pounds of water from freezing to boiling, which is almost precisely three times the effect.

III. 114. Table of the heating effects of different combustibles, according to Despretz:—

COMBUSTIBLE AND QUANTITY.	EFFECT.
<i>One Pound of each of the following :</i>	<i>Pounds of Water raised from the freezing to the boiling point, i. e., from 32° to 212° F.</i>
Charcoal,	78
Wood, having $\frac{1}{5}$ Water,	27
Alcohol,	68
Oil,	90
Hydrogen,	236

85. The most powerful effect of the burning of H. is seen only in connection with the *Hydro-Oxygen Blowpipe*, a contrivance for burning a stream of H. in conjunction with one of O.

This produces the hottest fire known, and is capable of fusing most solid substances, and of consuming all combustibles. By it all the metals are fused, and by the same means they are burned, that is, oxydized, and even dissipated in vapor. Its flame thrown upon Lime, causes the Lime to glow with the most intense light.

This light is known as the Lime, or Drummond light. Drummond originally made it by directing a jet of O. through the flame of a lamp upon a ball of Lime, by which means a nearly equal effect is produced.

Do theory and experiment agree? How is this proved in respect to H. and C.?

85. How is the greatest effect of the heat from burning H. obtained? What is the Hydro-Oxygen blowpipe? What kind of fire does it produce, and what are its effects? Its effects on metals? What is the Lime, or Drummond light? How did Drummond make it?

III. 115. The Hydro-Oxygen blowpipe, arranged with concentric jets (fig. 29), and two arms: one continuous in direction with the jets, to which the tube supplying the O. is attached; the other at right angles, for the H.

III. 116. Iron rapidly burned in its flame; Oxyds of Iron, Fe_2O_3 and Fe_3O_4 , formed.

III. 117. Zinc burned with the formation of a cloud of Oxyd of Zinc, ZnO , which constitutes the best white paint.

III. 118. Tin burns with a purple flame; Oxyd of Tin, SnO_2 , formed.

III. 119. Lead is converted into *litharge*, a yellowish brown Oxyd of Lead, PbO .

III. 120. Bismuth burns, forming a whitish cloud of Oxyd of Bismuth.

III. 121. Antimony rapidly oxydized.

III. 122. Silver converted into a cloud of smoke.

III. 123. Copper produces a green flame and a splendid green light.

III. 124. A small piece of Lime glows with an intense white light.

III. 125. Platinum, which is fused in no other fire, rapidly melts.

III. 126. Steel burns with showers of star-shaped scintillations, peculiar to the burning of Carburet of Iron.

III. 127. Cast Iron burns with thousands of brilliant sparks.

86. This blowpipe flame, previously stated to be the hottest of all fires, is a mass of O. and H. combining together and forming water. Its heat is equalled in intensity only by the action of the electricity of the galvanic battery, which is not, properly speaking, a fire.

The most powerful galvanic batteries have produced effects exceeding those of this blowpipe; but the operation of these batteries is generally dependent, in part at least, on the decomposition of water. It is therefore in connection, either with the formation or the destruction, of water, that the highest known temperatures are produced.

The measurement of these very high temperatures is entirely beyond the capacity of the common thermometers; but the heat necessary to fuse Platinum has been estimated to be of an intensity equal to three or four thousand degrees of Fahrenheit's scale.

Describe a form of the Hydro-Oxygen blowpipe, 115? Appearance and product from burning Iron, 116? Zinc, 117? Tin, 118? Lead, 119? Phenomena of burning Bismuth, 120? Antimony, 121? Silver, 122? Copper, 123? Heating Lime, 124? Effect on Platinum, 125? Steel, 126? Cast Iron, 127?

86. Describe the Hydro-Oxygen blowpipe flame, its products and comparative results? Heating effects of galvanic batteries? On what do these batteries generally depend? The connection of water with the production of high temperatures? Measurement of very high temperatures?

Ill. 128. Gunpowder flashed, and Iron rendered incandescent, or fused, by the galvanic battery.

87. From what has appeared, H. is seen to be an element of great importance. Its chief artificial uses are in aëronautics, and for the Hydro-Oxygen blowpipe which is employed for fusing Platinum, soldering Lead without the use of any other metal, and in scientific research and illustration. In nature, H. plays an important part, as it is an animal, vegetable, and mineral element, and exists especially in the coloring matters of plants. It constitutes a part of the food we eat, as well as of the water we drink.

88. H. has intimate chemical relations with the metals, which are next to be noticed; but it will be well first to take a retrospective view of the fourteen non-metallic simples already described. These are—

- | | | |
|------------------|-------------------|--------------------|
| 1. Iodine, I. | 5. Oxygen, O. | 9. Nitrogen, N. |
| 2. Bromine, Br. | | 10. Phosphorus, P. |
| 3. Chlorine, Cl. | 6. Sulphur, S. | |
| 4. Fluorine, F. | 7. Selenium, Se. | 11. Carbon, C. |
| | 8. Tellurium, Te. | 12. Silicon, Si. |
| | | 13. Boron, B. |

And 14. Hydrogen, H.

Ill. 129. Specimens of I., Br., Cl., O., S., Se., N., P., C., and H.

Ill. 130. Specimens of fluor spar, quartz, and borax; the first containing F., the second Si., and the third B.

89. The grouping of these simples according to their chemical relations will be referred to farther on. They may now be grouped in accordance with their usual mechanical forms as solids, liquids, and gases, and otherwise compared as follows:

Eight solids, viz., I., S., Se., Te., P., C., Si., and B.

Five gases, viz., Cl., F., O., N., and H.

One liquid, viz., Br.

Of the solids, C., Si., and B., are infusible, or perhaps in case of C. fusible, though with the greatest difficulty. They are

Heating effects of the galvanic battery, 128?

87. Importance of H.? Uses? Uses of the Hydro-Oxygen blowpipe? Part of H. in nature?

88. To what class of substances is H. related? Mention the fourteen Non-metals and their symbols? Mention only those you have had in an isolated state before you? What substances are exhibited as containing F., Si., and B., 130?

89. How many and which of the non-metals are usually solid? gaseous? liquid? Effect of heat on C., Si., and B.?

fixed in the fire; and heat, without access of air, has no other effect than to convert them to allotropic conditions, in which they are less readily acted upon by chemical agents.

I., S., Se., and Te., are easily fused, generally at moderate temperatures, and all below a red heat. They are also readily vaporized; and, instead of belonging to the class of *fixed* substances, like C., Si., and B., are classed among the *volatile* substances.

Of the *gases*, Cl. and F. are freely soluble in water, and are also condensible by pressure into limpid liquids.

N., H., and O., are very moderately soluble in water, and have heretofore proved unliquefiable.

The liquid, Br., may, without difficulty, have either the solid form or that of vapor.

Of the 14 simples, O., N., and H., are colorless, tasteless, and inodorous: the same may be said of C., especially in the form of diamond. All the others have some sort of color; I., Br., Cl., F., and S., are remarkable for their strong odor, and they all have some taste.

90. In their relations to burning, I., Br., Cl., F., and O., sustain the burning of substances that may be consumed in the air, but they do not burn in air, nor by means of O. These five simples have therefore received the titles of *supporters of combustion*.

N. neither burns nor supports burning.

Ill. 131. P. burned in the vapor of I. and Br., also in gaseous Cl. and O.; while none of these four latter substances take fire.

Ill. 132. When a taper is introduced into N., neither the N. nor the taper burns.

S., Se., Te., P., C., Si., B., and H., are combustibile in air, burning by combining with O., and forming Oxyds or acids. They are hence called combustibles.

Ill. 133. S. and P. burned in O.

Ill. 134. A mixture of charcoal and Chlorate of Potassa, if ignited, produces, by means of the O. of the Chlorate of Potassa, a very rapid burning, showing the ready combustibility of pulverized coal.

Mention the solids that are readily fused and vaporized? Which of the solids are *fixed*, and which *volatile*? Forms of Br.? Which of the simples are without color, taste, and odor? Mention those gases which are readily soluble and liquefiable, and those which are not? Mention the simples which have color? taste? odor?

90. Relations of I., Br., Cl., F., and O., to burning? Of N.? Which of the simples have been termed supporters of combustion? In what substances is P. burned, 131? P. in N., 132? Mention the non-metals that are combustibile in air, and tell how they burn? How are S. and P. burned, 133? Charcoal, 134?

The five simple gases, Cl., F., O., N., and H., have been seen to act very differently in respect to burning. O., N., and H., being alike invisible and inodorous, are not easily distinguished, unless tested in this relation. For want of a ready process for obtaining F., it is omitted in the illustrations.

Ill. 135. A wax taper in Chlorine burns faintly, with a copious smoke, or is extinguished, because Cl. has a sufficient attraction only for the H. and not for the C. of the wax. The Cl. does not take fire. In O., the taper burns brilliantly, since O. combines rapidly with both C. and H. In N., neither the taper nor the N. burns; and in H. the taper is extinguished, while the H. lights.

90, *a.* O. and H., the two elements of water, may thus be contrasted with each other:—

OXYGEN		HYDROGEN
is heavier than air;		is lighter than air;
does not burn in air;		burns in air;
promotes burning and breathing.		does not promote burning and breathing.

Both

exist in water;
are gases;

are without { color,
taste,
and odor.

91. The chief characteristic properties, uses, &c., of the non-metallic simples are as follows:—

I. forms a violet vapor, is contained in sponge, and is used in medicine.

Br. has a powerfully pungent, fetid odor; is a deep red liquid, and is used in photography.

Cl. has a yellowish green color, is an element of common salt, and is used in bleaching and disinfection.

F. combined with H. acts on glass, and is used for etching.

O., the most abundant element, powerfully stimulates burning, and is concerned in all ordinary fires.

S., when burned, gives the well known smell of Sulphurous

Which are the five simple gases? Why are O., H. and N., not easily distinguished, and how may this be done? Describe (135) the action of a burning taper in Cl., O., N., and H.?

90. *a.* State the contrasts and resemblances between O. and H.?

91. Mention the characteristic properties, uses, &c., of I.? Br.? Cl.? F.? O.? S.?

acid, and is chiefly used in the manufacture of oil of vitriol or Sulphuric acid.

N. is an element in air, in flesh, and in nutritious food. It is remarkable for its inertness.

P. shines in the dark, is extracted from bones, and used in the manufacture of matches.

C., in the diamond, is the hardest of all substances. As graphite, its use for pencil points is important.

Si., the most abundant simple after O., is an element of sand and of most rocks; its compounds give stiffness to the straw of wheat, &c., and it is an element of glass, porcelain, and earthenware.

B. is found in volcanic vapors, and as an element of *borax*, which is employed in welding Iron, and Tinning Copper.

H., the lightest known substance, is an element of water, and is used for producing extreme heat, and for ballooning.

Ill. 136. Characteristics, &c., of the non-metallic simples :—

a. Art. 9, *Ill.* 14. A violet vapor.

b. Art. 16. A Daguerreotype.

c. 20, *Ill.* 35. Bleaching Indigo.

d. 25, *Ill.* 43. An Etching.

e. 66, *Ill.* 83. An invisible gas, in which coal undergoes a brilliant combustion.

f. 45. A substance burning with a purple flame and pungent odor.

g. 52. A quantity of corn.

h. 56, *Ill.* 73. A substance that takes fire by slight friction.

i. 65. "Lead" pencils.

k. 73. Straw burned, and its ashes fused into a glass bead.

l. 74. Borax.

m. 78, *Ill.* 94. Soap bubbles that rise through the air.

92. The remaining simple substances are generally considered to be metals, although one or two of them have sometimes

N. ? P. ? C. ? Si. ? B. ? H. ? What are the several illustrations, 136, of I. *a.* ? Br. *b.* ? Cl. *c.* ? F. *d.* ? O. *e.* ? S. *f.* ? N. *g.* ? P. *h.* ? C. *i.* ? Si. *k.* ? B. *l.* ? H. *m.* ? What simple substance forms a violet vapor ? What one is used in producing Daguerreotypes ? Bleaching Indigo ? Etching ? In what gas does charcoal burn rapidly ? What burns with a purple flame and pungent odor ? What simple is a peculiar element of corn ? What inflames by slight friction ? Constitutes pencil points ? Is contained in straw and glass ? In borax ? In ascending soap bubbles ?

92. After the first fourteen simples, what are the remaining ones considered to be ?

been included among the non-metallic simples; and on the other hand, Silicon, by some Chemists, has been regarded as a metal, and called Silicium.

The metals do not differ, in chemical properties, from the non-metals; as, for example, H. and Zinc have strong resemblances, and so also have P., Arsenic, and Antimony. The three characteristic properties of metals have been stated to consist, *firstly*, in the superior power of conducting heat; *secondly*, in their capacity of conducting electricity; and, *thirdly*, in a well known peculiar brilliancy or susceptibility of polish, called the *metallic lustre*.

These are purely mechanical, and not chemical properties; and the division of the simples into metals and non-metals, is simply a mechanical or physical one.

Ill. 137. The conduction of heat by metal shown, in heating one end of a metallic rod, along which some pieces of P. are placed at equal distances. As the heat is conducted through the rod, the pieces of P. inflame at regular intervals of time.

Ill. 138. That metal conducts electricity, is illustrated in firing a miniature cannon at the further side of the room, by means of a wire stretched across from a galvanic battery.

93. There are certain other properties which are common to many of the metals, but which are not universal with whole classes, and can not therefore be reckoned characteristic. Among these may be mentioned *malleability*, *ductility*, and *tenacity*.

Malleability, or the capability of being hammered into thinner plates or sheets, is possessed in the highest degree by Gold, and to an inferior extent by Silver, Copper, Tin, Lead, Iron, and some others.

Ill. 139. Gold leaf, which is so thin and has so much surface as to float almost as well as feathers, when blown into the air.

Ductility, or the capability of being drawn into wire is seen in Platinum, Silver, Copper, and Iron. Iron is the most *tenacious* of the common metals; though, if some recent experiments are correct, Cobalt has twice its strength. Copper is about half as tenacious as Iron.

What variation from this is noticed? Chemical properties of the metals? Mention examples of resemblances between metallic and non-metallic substances? How many and what characteristics have metals? What sort of a distinction is that between metals and non-metals? How is the capability of metal to conduct heat illustrated, 137? To conduct Electricity, 138?

93. What properties are mentioned as common rather than characteristic, and why? What is *malleability*, what metals possess it, and in what degree? What is done with Gold leaf, 139? Ductility? Which is the most tenacious metal? Tenacity of Copper?

94. The metals have been grouped in various ways. The seven metals, Potassium, Sodium, Lithium, Barium, Strontium, Calcium, and Magnesium, which, combining with O., form alkaline substances, may be grouped together, and will be first considered.

The fifteenth simple to be noticed, is, therefore—

POTASSIUM, K. *Eg.* 39. *D.* .865; *Water*, 1.

95. This is one of the most important simples, and is tolerably abundant, though never found naturally in a simple state. It is an element of animal and vegetable bodies, of fertile soils, and of some extensive minerals, such as *feldspar* and *mica*.

Ill. 140. Specimens of *mica* and *feldspar*.

The extraction of K. is a difficult chemical operation, making it comparatively rare and costly in the pure condition. Many of its artificial compounds are derived from potash, which is extracted from the ashes of plants.

The ashes are leached by pouring water upon them, and thus dissolving the more soluble substances which they contain. This water, then known as *lye*, is heated in large iron pots, so as to expel the water, and leave the dissolved matter in the solid state. This solid residue is *potash*.

96. Potash is a variable mixture of Hydrate of Potassa, KO.HO., Carbonate of Potassa, KO.CO₂, and other substances. The Hydrate of Potassa consists of Potassa, KO, and water, HO. The Carbonate contains Potassa and Carbonic acid, CO₂. Potassa consists of Potassium, K., and Oxygen, O.

Ill. 141. Specimens of potash, of Hydrate of Potassa, and of Carbonate of Potassa.

The three terms potash, Potassa, and Potassium, are derived from the process of evaporating the lye of ashes in iron pots. Both potash and Potassa are sometimes called potash, but the practice should be discontinued, in order to prevent confusion.

94. In the first place what seven metals are grouped together, and why? Name, symb., equiv., and density of the fifteenth simple? Mention in order the first fifteen simples and their symbols?

95. Importance and abundance of K.? In what state and in what substances found? What minerals are exhibited (140) as containing K.? Why is pure K. rare and costly? From what are artificial compounds of K. derived? From what is potash extracted, and how?

96. Of what substances is potash composed, and what are their symbols? Of what does the Hydrate consist? The Carbonate, and the symbols of its elements? Potassa? What substances are exhibited (141) as containing KO.? Origin of the names Potassa, Potassium, and potash? Proper use of the terms Potassa and potash?

In some parts of Europe, potash and Potassa are known as *kali*, whence Potassium is termed Kalium, and its symbol is written K.

97. K. in its simple state is a solid, but is fused at 151° , and vaporized below a red heat. It is so soft as to be compressible between the thumb and fingers, and so light (sp. gr. .865) as to float on water. It has a bluish tint, and a brilliant metallic lustre, like newly cut Lead.

Ill. 142. The shining lustre of a freshly cut surface of K.

Ill. 143. A piece of K. flattened by slight pressure.

98. K. has exceedingly energetic attractions for other simples. Its affinity for O., under favorable circumstances, is greater than that of any other simple, so that it is capable of decomposing all the compounds of O.

On this account, K. can not be kept in air, and is usually preserved in mineral Naphtha, which consists only of C. and H.

Ill. 144. K. rapidly tarnished in air by combining with O.

Ill. 145. K. thrown into water, combines with O. energetically, producing heat sufficient to inflame the liberated H., and to fuse the metal into a globule, which floats, gradually wasting away upon the water (fig. 30).

Fig. 30.



Potassium burning on Water.

Ill. 146. Ice used to light a lamp, upon the wick of which a small piece of K. has been placed.

Ill. 147. Gunpowder fired by means of ice and K.

Ill. 148. K. takes fire when laid on ice.

Ill. 149. K. burns in Carbonic acid by combining with its O., while the C. is liberated as a sooty deposit; this being the only case in which Carbonic acid supports burning.

Ill. 150. That H. is liberated from water by the action of K., is shown when K. is introduced into a glass of water, inverted in water; an invisible and combustible gas being collected.

Ill. 151. An explosion by introducing K. into an inverted glass of water containing air; the H. liberated forming an explosive mixture with the air.

Ill. 152. The purple flame noticed in the burning of K. is seen also in the tint of the blowpipe flame when it is thrown on Carbonate of Potassa, or any compound of K.

Why is K. the symbol of Potassium?

97. Form, fusibility, volatility, softness, and levity, of K.? Color and appearance? Freshly cut surface of K., 142? Pressure, 143?

98. Attractions of K.? For O.? How kept, and why? Exposure, 144? K. thrown into water, 145? Lamp lighted with ice, 146? Gunpowder, 147? K. on ice, 148? In Carbonic acid, 149? How is it shown that K. liberates H. from Water, 150? Explosion by means of K., 151? Purple flames produced, 152?

III. 153. Red cabbage water turns green when K. is burned on its surface, in consequence of the formation of Potassa, an alkaline substance which, like other alkalies, changes certain vegetable colors to green.

III. 154. The blue color of litmus water that has been reddened by an acid, is restored by dropping in K., as the alkali formed neutralizes the acid.

III. 155. Yellow turmeric water is darkened by KO ., as by other alkaline substances.

99. These illustrations show K. to be a most remarkable substance, having many characteristic properties. It is the lightest metal; of the solid metals, it is the softest and most readily fusible. No other metal has so strong an attraction for O.

It is used in the laboratory to decompose and deoxygenize substances that can not be otherwise readily decomposed. The compounds of K. have extensive natural and artificial uses.

The sixteenth simple, Sodium, has much resemblance to K., and is only exceeded by that substance in the extreme energy of their common properties.

SODIUM, Na. *Eq. 23. D. .972; Air, 1.*

100. Na. is quite abundant, though found only in the combined state. It is an element of common salt and some other minerals, and is generally present in animal and vegetable bodies.

The artificial compounds of Na. are now exclusively formed from common salt, which, as before noticed, consists of Cl. and Na.

Soda, NaO ., composed of Sodium and Oxygen, is the substance from which Na. takes its name. The symbol is from Natrium, a Latin name for Na. Natrium is derived from *natron*, an ancient name for Carbonate of Soda.

Na., like K., is obtained pure, only by a difficult operation.

III. 156. Specimen of Carbonate of Soda.

101. Na. is a brilliant, silvery white metal, heavier and harder

Red cabbage water turned green, 153? Reddened litmus turned blue, 154? Effect on turmeric water, 155?

99. What remarkable characteristics of K. are mentioned? Uses of K. and its compounds? The sixteenth simple, and its resemblance to K.? Names and symbols of the first sixteen simples in order? Symbol, equivalent, and density, of Na.?

100. Abundance and state of Na.? What substances contain it? Its artificial compounds derived from what? Symbol and composition of Soda? Derivation of name and symbol of Na.? How obtained pure? Substance exhibited (156) containing Soda?

101. Appearance, heaviness, and hardness, of Na.?

than K., but still lighter than water, and capable of being moulded by the fingers. It fuses at 194° .

Ill. 157. Specimen of Na. preserved in Naptha.

Ill. 158. Lustre when newly cut, and softness of Na.

102. The following illustrations show that the chemical properties of Na. are very similar to those of K.

Ill. 159. Na. soon tarnishes by oxydation when exposed to air.

Ill. 160. A piece of Na. in water, fuses by the heat resulting from its rapid oxydation. It combines with the O. of the water, and forms Soda, NaO . The H. is liberated in minute bubbles, which push the melted metallic globule briskly about on the surface of the water, while a hissing sound is heard. If the water is cold, the Na., unless kept quiescent, or in large quantity, does not take fire.

Ill. 161. In hot water, Na. produces fire, often with an explosion, before which the H. of the water burns with a flame tinged yellow, by the presence of a Sodium compound.

Ill. 161, *a.* A piece of K. and one of Na., pressed together and laid on ice, produce an explosion, with fine coruscations of fire.

Ill. 162. A yellow tinge imparted to the blowpipe flame when projected on Carbonate of Soda, or on other compounds containing NaO .

Ill. 163. H. in notable quantity liberated on the introduction of Na. into an inverted test glass of water.

Ill. 164. The alkaline reaction, seen when Na. is put into red cabbage, reddened litmus, and turmeric water; the Soda which is formed being an alkali, and changing the cabbage water to a green, restoring the blue of the litmus, and browning the turmeric.

103. Na. in its simple condition is only employed for illustration. Its importance is indicated by the previous mention of the substances which contain it. It is an indispensable element in fertile soils. (See appendix.)

104. The five other metals of the group, Lithium, Barium, Strontium, Calcium, and Magnesium, have properties similar to those of K. and Na., but they are less energetic in their affinities.

The seventeenth simple—

105, LITHIUM, L., is not abundant, being found only in a few comparatively rare minerals, as *spodumene* and *lithia mica*. Its

Fusibility? Na. is how preserved? What properties are readily shown, 158?

102. Chemical properties of Na. similar to those of what? Na. how tarnished, 159? Na. on cold water, 160? Product and symbol? Na. on hot water, 161? Color of the flame, and why? Explosion, 161, *a.*? Yellow tinge how given to the blowpipe flame, 162? H. how liberated, 163? Action on red cabbage, reddened litmus, and turmeric water, and why, 164?

103. Uses and importance of Na.? Fertile soils?

104. Properties of the remaining five metals of the group?

105. Name, symbol, and abundance, of the seventeenth simple? In what minerals found?

name has been formed from the Greek *lithos* a stone. Some of its salts are medicinal.

Ill. 165. Specimen of spodumene.

The eighteenth simple—

106, BARIUM, Ba., is quite abundant in the mineral known as *heavy spar*, and its name has therefore been formed from the Greek *barus*, signifying heavy. Ba. is also contained in native Carbonate of Baryta, BaO, CO_2 . Heavy spar is Sulphate of Baryta, BaO, SO_3 , consisting of the Oxyd of Barium, called Baryta, BaO., and Sulphuric acid, SO_3 .

Ill. 166. Specimens of heavy spar, and of Witherite, the native Carbonate of Baryta.

107. All the soluble salts of Ba. are poisonous. The antidote to their poisonous effects is Sulphate of Magnesia (Epsom salt), or some other soluble sulphate, which converts the Ba. salt into Sulphate of Baryta, and this is insoluble, and therefore harmless.

Ill. 167. When solutions of Chlorid of Barium, BaCl ., and Sulphate of Magnesia, MgO, SO_3 ., which are separately transparent, are mixed, the mixture becomes milk-white and turbid from the formation and precipitation of Sulphate of Baryta; Chlorid of Magnesium, MgCl ., is also formed. Thus BaCl and MgO, SO_3 give rise to BaO, SO_3 and MgCl .

108. Ba. is not used in the simple state. The Sulphate of Baryta is employed as a white paint, and also to adulterate more costly paints.

The nineteenth simple—

109, STRONTIUM, Sr., exists in *celestine*, which is Sulphate of Strontia, SrO, SO_3 , and in *Strontianite*, or Carbonate of Strontia, SrO, CO_2 .

Sr. was originally found near the Scottish town of Strontian, whence the name. It occurs in a few other minerals.

Why so called? Mineral (165) containing L.? Mention the first seven-
teen simples, and give their symbols?

106. Name, symbol, abundance, &c., of the eighteenth simple substance? Mention the first eighteen simples? Origin of the name of Ba.? Symbol of the Carbonate and of the Sulphate of Baryta? Minerals exhibited (166) containing Ba.?

107. Properties of the salts of Ba.? Antidote, and why? Symbol of Chlorid of Barium and of Sulphate of Magnesia? Products of the reaction (167) between BaCl and MgO, SO_3 ? Why, and the symbols?

108. Use of simple Ba.? Of BaO, SO_3 ? Name and symbol of the nineteenth simple? Names and symbols of the whole nineteen?

109. In what is Sr. found? Symbol of the Carbonate and Sulphate of Strontia? Origin of the name of Sr.?

Sr. is not an important substance. Its compounds give a red color to flame, and some of them are employed in Pyrotechny to produce red fire.

Ill. 168. Specimens of celestine and Strontianite.

Ill. 169. The flame of alcohol tinged of a fine red by the presence of Sr.

The twentieth simple—

110, CALCIUM, Ca., *Eq. 20*, is a very abundant and important element, existing in mineral, vegetable, and animal bodies. It is the metallic base of Lime, and its name is from the Latin *calx*, chalk or lime.

Lime is an Oxyd of Calcium. Limestone, or *calcite*, from which lime is obtained, and which constitutes the marbles, is Carbonate of Lime, CaO, CO_2 , consisting of Lime, CaO , and Carbonic acid, CO_2 . No soil can be fertile that does not contain Ca.

Ill. 170. Specimens of *calcite*.

The twenty-first simple—

111, MAGNESIUM, Mg., is an abundant simple. It is an element of animal and vegetable bodies, and consequently of fertile soils. *Magnesia*, MgO , which consists of O. and Mg., and is therefore Oxyd of Mg., exists in such extensive minerals as *magnesian limestone*, *talc*, *serpentine*, and *chlorite*. Several of the compounds of Mg. are used in medicine, but the simple metal is not applied to any purpose.

Ill. 171. Specimens of artificial preparations of Mg., viz., MgO . and Carbonate of Magnesia, MgO, CO_2 .

Ill. 172. Specimens of *talc*, *serpentine*, and *chlorite*.

112. By suitable means, the presence of any of the compounds of these metals, in solution, may be detected. For example, the compounds of K. and Na. are nearly all very soluble in water,

Its importance? Its compounds, flame, and Pyrotechny? Minerals exhibited containing Sr., 168? Flame of alcohol, how tinged red, 169?

110. Name, symbol, and equivalent, of the twentieth simple? Names and symbols of the whole twenty? Abundance and importance of Ca.? Ca. exists where? Is the metallic base of what? Origin of its name? What is Lime? Limestone or Calcite, and what does it constitute? Composition and symbol of Carbonate of Lime? Ca. and fertile soils? Minerals exhibited (170) containing Lime?

111. Name, symbol, and abundance, of the twenty-first simple? Names and symbols of the twenty-one? Of what is Mg. an element? What is Magnesia, and why? Where does it exist? Use of Mg. and its compounds? Artificial preparations (171) containing Mg.? Minerals, 172?

112. Detection of compounds of the metals of the alkalies? Of K. and Na.?

and this characteristic is one that favors the determination of their presence. The soluble compounds of Ba. are precipitated by a sulphate, as previously noticed, and are thus recognised, while the soluble compounds of Ca. are precipitated by Oxalate of Ammonia.

III. 173. Solution of Oxalate of Ammonia added to Lime water produces a white precipitate of Oxalate of Lime.

The Oxalate of Ammonia consists of Oxalic acid and Ammonia. The acid leaves the Ammonia, and combines with the Lime.

113. The next to be noticed are

THE METALS OF THE EARTHS.

They are the seven following:—

- | | | |
|-------------------|-----------------|-------------------|
| 1. Aluminum, Al. | 3. Yttrium, Y. | 5. Zirconium, Zr. |
| 2. Glucinum, G. | 4. Thorium, Th. | 6. Cerium, Ce. |
| 7. Lanthanum, Ln. | | |

114. These seven metals combine with O., and form substances called earths. The earthy Oxyds differ from the alkaline Oxyds in not being caustic nor destructive to animal and vegetable tissues, and in not changing vegetable colors. Like the alkalies, however, the earths form salts by combining with acids.

115. ALUMINUM, Al., is the most important metal of this group. Its name is formed from the Latin, *alumen*, alum, which contains Al. Aluminum is very abundant in nature, being an element of *granite, feldspar, clay, emery, slate*, and many other minerals and rocks. In these it is combined with O., to form the earthy oxyd Alumina, Al_2O_3 . The sapphire, one of the most valuable precious stones, and emery, are pure Alumina.

III. 174. Specimens of granite, feldspar, emery, and alum.

Of Ba. ? Of Ca. ? Reaction between Oxalate of Ammonia and Lime water, 173; its result, and why?

113. Names and symbols of the second group of seven metals ? Repeat in order the fourteen metals which have now been mentioned ? How are the second group designated ?

114. How do these metals form earths ? Characteristics of the earthy oxyds ? In what are they like the alkalies ?

115. Most important metal of group 2 ? Origin of its name, and why ? Abundance of Al. ? What mineral substances contain Al., and in what state ? Pure natural forms of Al_2O_3 ? Natural substances exhibited, 174, containing Al. ?

Ill. 175. Specimen of Al_2O_3 chemically prepared.

Ill. 176. The color of turmeric water unaffected by Al_2O_3 , which is therefore not alkaline.

Ill. 177. The blue color of reddened litmus water is not restored by Al_2O_3 , illustrating that this oxyd does not readily neutralize acids.

The remaining metals of this group are quite unimportant. They are found only in a few rare minerals or precious stones. Glucinum is an element in the emerald and beryl.

Next there are to be noticed the ten

METALS OF THE STRONG BASES.

116. These are—

- | | | |
|-------------------|----------------|-----------------|
| 1. Manganese, Mn. | 4. Nickel, Ni. | 7. Cadmium, Cd. |
| 2. Iron, Fe. | 5. Cobalt, Co. | 8. Lead, Pb. |
| 3. Chromium, Cr. | 6. Zinc, Zn. | 9. Uranium, U. |
| 10. Copper, Cu. | | |

The oxyds of the metals of this group differ from those of the metals previously noticed, since they are not caustic and alkaline like those of group one, nor white earths like those of group two.

Unlike the group to be immediately hereafter noticed, the oxyds of these metals are strong bases, capable of neutralizing acids by combining with them and forming salts.

Five of them Mn., Cr., Co., Cd., and U., are not in common use as metals, but the others are frequently seen and more or less used, in the simple metallic condition.

117. MANGANESE, Mn., is abundant in nature as a black Oxyd, MnO_2 , which is a substance extensively employed in the arts. Its uses in obtaining Cl. and O. have been referred to Art. 17, 28.

Ill. 178. Specimen of MnO_2 .

Artificial, 175! Action of Al_2O_3 on turmeric water, 176, and what is proved? On reddened litmus, 177, and what is proved? Importance of the other six metals of group 2? Where found? What class of metals is next to be noticed?

116. Names and symbols of the ten metals of group 3? Also of the 24 metals now mentioned? Distinction between the Oxyds of the metals of group 3, and those of groups one 1 and 2? Difference between the Oxyds of group 3, and those of group 4? Names of the five metals of group 3, which are not in common use as metals? Of the five which are?

117. What is said of Mn. and MnO_2 ? Substance exhibited, 178, containing Mn?

118. IRON, Fe., *Eq.* 28, *Dens.* 7.8, is the most useful of the metals.

Like many other metals it is found *native*, and *mineralized*, or in the state of an *ore*.

A metal is said to be *native* in those cases in which it occurs either pure, or combined with another metal.

Combinations, whether natural or artificial, of different metals, with each other, are called *alloys*.

An *ore* of a metal is a natural combination of it with some non-metallic substance; and this is termed the *mineralizer*.

Native Iron is found alloyed with Ni., in meteoric masses. One of these in South America is estimated to weigh 30,000 lbs.; smaller masses are not uncommon.

All meteoric Iron is considered to have fallen to the earth from some ultra-terrestrial source. Non-meteoric native Iron is very rare.

The chief ores of Fe. are *magnetite* or the black Oxyd; Fe_3O_4 *specular Iron*, or the Sesquiöxyd, Fe_2O_3 ; *limonite*, or the hydrated Sesquiöxyd, $\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$; and *spathic Iron*, or the Carbonate $\text{FeO} \cdot \text{CO}_2$.

From these ores it is extracted by the action of Carbon, limestone, and intense heat, in powerful blast furnaces.

III. 179. Specimen of Iron ores.

119. The properties of Fe. are remarkable. As already mentioned, it is the strongest of the common metals. Unlike most other metals it is capable of being *welded*; that is, separate pieces may, by heating, be softened and hammered into a single piece.

Fe., by combining with C., forms *steel* and *cast Iron*. The former is used for springs, cutlery, &c., and the latter is the material for hollow Iron ware, and for all those portions of Iron machinery which are not forged.

In nature, Iron serves important purposes, being an element of animal and vegetable, as well as of mineral bodies.

The symbol, Fe., is an abbreviation of *ferrum*, the Latin name.

120. CHROMIUM, Cr., is abundant in nature in combination with Fe. Several beautifully colored substances are manu-

118. Symbol, equivalent, and density of Iron? Its usefulness? Found in what conditions? What is a native metal? An alloy? An ore? A mineralizer? Native Fe. is how found? Masses? Source of meteoric Fe? Abundance of terrestrial native Fe? Names and symbols of the chief ores of Fe? How is the metal obtained? Distinguish the various ores exhibited, 179?

119. Two remarkable properties of Fe? How does it form steel and cast Iron? Their uses? Natural purposes of Fe? Its symbol, and why?

120. Symbol, abundance, and natural condition of Chromium?

factured from it such as *chrome yellow*, the Chromate of Lead, *chrome green*, an oxyd of Cr., and the yellow and red Chromates of Potassa.

Hence its name has been formed from the Greek, *chroma*, color.

Ill. 180. Specimens of native *chrome Iron*, and of colored artificial compounds of Cr.

121. NICKEL, Ni., is a metal of considerable use as an element of German silver.

Although all the metals are to some extent, and in some way, susceptible of magnetism, Fe. and Ni. are the only substances that are capable of becoming highly magnetic.

Ill. 181. Pieces of Ni. rendered magnetic and suspended by the horseshoe magnet.

122. COBALT, Co., is a tolerably abundant metal.

Its chief use arises from the effect of its Oxyd on glass, by which a fine blue is produced. This blue glass, when pulverized, is known as *smalts*.

Ill. 182. Specimens of *smalts* and of glass stained blue.

123. ZINC, Zn., *Eq.* 32.5, *Dens.* 7, is a well known metal of extensive use. Its Oxyd, ZnO, is a superior white paint.

The chief ores of Zn., are the Oxyd, ZnO, *blende*, or the sulphuret, ZnS, and the Carbonate, ZnO.CO₂.

Ill. 183. Zinc *blende* and native Oxyd of Zinc.

CADMIUM, Cd., and URANIUM, U., are rare metals without importance.

124. LEAD, Pb.,* *Eq.* 103.5, *Dens.* 11.4, is one of the heavier metals.

Its uses are well known.† *Galena*, the Sulphuret of Lead, PbS, is its only valuable ore.

Ill. 184. Specimen of *galena*.

* Latin, *plumbum*.

† "Lead" pencils are made of graphite, and contain no lead.

Colored substances? Origin of the name? Distinguish the compounds of Cr. exhibited, 180?

121. Symbol and use of Nickel? Magnetism? Ni. how rendered magnetic, 181?

122. Symbol, abundance, and use of Cobalt? Smalts?

123. Symbol, equivalent, and density of Zinc? Let the pupil mention uses of Zn. known to him? Use of its Oxyd? Ores of Zn.? Distinguish the different ores, 183? What is said of Cd., and U.?

124. Symbol, equivalent, and density of Lead? Why is Pb. the symbol? Uses known to the pupils? The ore of Pb.? its names and symbol?

Like those of Ba., all the soluble salts of Pb. are poisonous, and the antidote is the same, as in poisoning by compounds of Ba.; viz., Sulphate of Magnesia, or some soluble Sulphate, which converts the Lead salt into insoluble Sulphate of Lead.

Ill. 185. Solution of Acetate of Lead (*sugar of Lead*), with Sulphate of Magnesia (Epsom salts), gives a white precipitate of Sulphate of Lead.

125. COPPER, Cu., *Eq.* 31.7, *Dens.* 8.8, is a very important metal.

It is found native, and its ores such as an Oxyd, a Sulphuret, and Carbonates, are abundant.

Ill. 186. Native Cu. and Copper ores.

All the salts of Cu. are poisonous. The antidote is Albumin which, administered in the shape of eggs, converts the Copper to an insoluble and comparatively harmless compound.

Ill. 187. White of eggs coagulated by solution of Cu.

Ill. 188. That the oxyds of the metals of this group are strong bases, capable of neutralizing acids, may be illustrated by putting Oxyd of Lead, PbO (litharge), into reddened litmus. The red color will be destroyed, and a purple tinge take its place.

The metals of the fourth group, next to be noticed, when they combine with O., instead of forming strong bases that will neutralize acids, produce compounds that are either weak bases, having little attraction for acids, or, in some cases, substances that are themselves acid.

METALS OF THE WEAK BASES.

126. These are ten in number:—

- | | | |
|--------------------|------------------|------------------|
| 1. Vanadium, V. | 4. Columbium, or | 7. Bismuth, Bi. |
| 2. Tungsten, or | Tantalum, Ta. | 8. Antimony, Sb. |
| Wolfraimium, W. | 5. Titanium, Ti. | 9. Arsenic, As. |
| 3. Molybdenum, Mo. | 6. Tin, Sn. | 10. Osmium, Os. |

There are but three of the members of this group, Tin, Bis-

Salts of Pb.? Antidote, and why? Reaction, 185, between Acetate of Lead and Sulphate of Magnesia?

125. Symbol, equivalent, and density of Copper? In what conditions found? Designate the minerals exhibited, 186? Salts of Copper? Antidote, and why? White of eggs how coagulated, 187? What is illustrated by Oxyd of Lead, 188? Common characteristic of the metals of group 4? How is this group designated?

126. Names and symbols of the ten metals of group 4? Names and symbols of the thirty four metals now mentioned? How many, and what metals of the fourth group are important in the metallic state?

muth, and Antimony, that are of any importance in the metallic state. Arsenic is tolerably abundant. The six remaining metals are very rare and need no farther notice here.

127. TIN, Sn.,* *Dens.* 7.3, is found in few localities as in Cornwall, England, but in these in sufficient abundance. The only valuable ore is the Binoxyd, SnO_2 .

Sn. is made into *Tin plate*, by placing clean Iron sheets in fused Sn., by which means an alloy of the two metals is formed on the surface of the sheets. The uses of these sheets for roofing, making pans, cups, pails, and a multitude of culinary articles, are well known.

Sn. is alloyed with Cu. to form *bronze*, with Pb., for solder, and with Mercury to produce the reflecting surface of glass mirrors. Compounds of Sn. are employed in dyeing, and in staining glass crimson and purple.

Ill. 189. Specimens of Tin ore, of the pure metal, of bronze, and of crimson, and purple glass.

128. BISMUTH, Bi., is not a very abundant metal. An alloy containing it is used for soldering. Other alloys which are very fusible, are employed for moulds. An alloy, fusible at about 201° may be composed of one part Pb., one Sn., and two Bi.

Ill. 190. Specimens of Bi., and of an alloy fused by boiling water.

129. The chief ore of ANTIMONY, Sb.,† is a Sulphuret, SbS_2 . The metal is alloyed to make *type metal*, Britannia, and other compounds. Preparations of Sb. are common in medicine.

Ill. 191. Specimens of Sb., and SbS_2 .

130. ARSENIC, As., occurs native and nearly pure, but often in combination with other metals, also in Sulphurets. It has a dark grey color.

The common poison known as *white arsenic* and *ratsbane* is Arsenious acid, AsO_3 .

Ill. 192. Specimens of As., and AsO_3 .

* Latin, *stannum*, Tin.

† Latin, *stibium*.

Arsenic? The remaining six?

127. Symbol, density, natural localities and abundance of Tin? Its symbol why Sn.? Only ore? Tin plate? Bronze and solder? Mirrors? Uses of compounds of Sn.? Distinguish the specimens illustrating Sn., 189?

128. Symbol and abundance of Bismuth? Alloys? Specimens, 190?

129. Chief ore of Antimony? Symbol why Sb.? Uses of alloys, and preparations of Sb.? Specimens, 191?

130. Symbol and natural state of Arsenic? The common poison? Distinguish the specimens?

Next there is to be noticed the fifth group of metals. Having so little attraction for O., that they do not oxydize or "rust" by atmospheric influences, but retain their brilliancy, they are therefore called—

THE NOBLE METALS.

131. These are :—

- | | | |
|-----------------|------------------|-------------------|
| 1. Mercury, Hg. | 3. Gold, Au. | 5. Palladium, Pd. |
| 2. Silver, Ag. | 4. Platinum, Pt. | 6. Rhodium, R. |
| | 7. Iridium, Ir. | |

MERCURY, Hg.,* *Dens.* 13.5, is remarkable as a liquid, silvery metal at temperatures between -39.5° , its freezing point, and 662° , its boiling point, whence it is called *quicksilver*. Hg. is found native, but chiefly as a Sulphuret, HgS, known as *cinnabar*.

Alloys of Hg. are termed amalgams.

Ill. 193. Specimens of Hg. and of cinnabar.

The uses of Hg., for mirrors, thermometers, barometers, Daguerreotyping, the extraction of Gold, and in medicine, are well known.

Artisans incautiously exposing themselves to Hg., are liable to a peculiar inflammation of the mucous membrane, called mercurial salivation, since it produces a superabundance of saliva.

132. SILVER, Ag.,† *Dens.* 10.5, occurs abundantly in the native condition, and also in numerous ores.

Ill. 194. Specimens of native Cu., containing Ag., and of Silver ores.

GOLD, Au.,‡ and PLATINUM, Pt., are exclusively found in the metallic state. They are, except IRIDIUM, the heaviest known substances, the density of Ir. is 21.12, of Pt. 19.7 to 21.2, and of Au. 19.26.

Ill. 194, a. Specimens Pt., Ir., and of quartz containing Au.

* Latin, *hydrargyrum*.

† Latin, *argentum*.

‡ Latin, *aurum*.

Why is the fifth group designated *noble metals*?

131. Names and symbols of group 5? Names and symbols of the whole forty one now mentioned? Why is Hg. the symbol of Mercury? Density of Hg.? Remarkable property? Common name? Natural state? *Amalgams*? Designate the specimens in 193? Uses of Hg.? Caution?

132. Symbol of Silver, why Ag.? Density? Natural condition? Designate the specimens, 194? Symbol of Gold, why Au.? Symbol of Platinum? Natural condition of Au. and Pt.? Heaviness of Pt., Au., and Ir.? Specimens?

Pt. is acted upon by so few chemical agents, and sustains such high temperatures without fusion, that it is made into crucibles for chemical analysis; and thus has proved one of the substances most important to the advancement of science.

Pt. is fused only by the Hydro-Oxygen blowpipe, or the Galvanic battery.

IRIDIUM, is a very hard metal, and is used in giving the "diamond point" to gold pens.

The remaining metals of this group are very rare. They occur in connection with Pt.

133. It has been already noticed that, by proper tests, the presence of metallic substances in solution is readily detected. The following reactions are among the more interesting.

III. 195. Solution of Fe. gives, with Tannic acid, a blackish precipitate, which is common writing ink, or Tannate of Iron. With Ferrocyanid of Potassium, Fe. gives a blue Ferrocyanid of Iron (Prussian blue), and with Ammonia, a brown hydrated Sesquioxyd of Iron.

III. 196. Solution of Cu, with Ferrocyanid of K, gives a brown, and with a very slight quantity of Ammonia, a pale green precipitate which becomes a beautiful deep blue with more Ammonia.

III. 197. Solution of Acetate of Lead, with Bichromate of Potassa gives Chromate of Lead (chrome yellow).

III. 198. Solution of Nitrate of Silver, with solution of Chlorid of Sodium (common salt), produces a white precipitate of Chlorid of Silver, AgCl.

III. 199. Chlorid of Mercury, acted upon by Iodid of Potassium in solution, produces a fine red Iodid of Mercury, HgI.

III. 200. Dark precipitates are produced from solutions of Cu, Fe, Pb, and Ag, by solution of Sulphydric acid, which gives precipitates with most metallic solutions, and is on that account in frequent use in analytical operations.

134. There remain a few rare and more recently discovered metals un-referred to. Of these, *Didymium*, *Erbium*, *Terbium*, *Niobium*, *Norium*, and *Ruthenium*, may be mentioned. If *Pelopium* and *Ilmenium*, which are somewhat doubtful, are included, there will be eight in all, which, as their properties are better understood may be introduced in previous groups.

Including these 8, the 7 noble metals, the 10 metals of the weak bases, the 10 of the strong bases, the 7 of the earths, and

Uses of Pt, and why? Fusibility of Pt? Use of Ir? Other metals of the group?

133. Detection of metallic substances? Describe the reactions of Fe, 195? Of Cu, 196? Of Pb, 197? Of Ag, 198? Of Hg, 199? Of various metals with Sulphydric acid?

134. What is said of the remaining metals? Names? What disposition will yet be made of these? Mention the groups, number in each group, and their names, and sum up the whole number of metals?

the 7 of the alkalies, there is a total of 49 metals, and with the 14 non-metals, 63 *simple substances*.

Having now given to the simples as much attention as has been judged profitable, it will be next in order to notice compound substances; and first those that consist of two simples and are therefore termed—

BINARY COMPOUNDS.

135. Since the Chlorine group of simples was first noticed, it will be proper, to first take the binary compounds of that group. These compounds are known generally as Iodids, Bromids, Chlorids, and Fluorids.

Those of them that contain Hydrogen are called *Hydracids*, as their solutions have acid properties, while those that contain metals are called *Haloid Salts*.*

The first of these substances possessing sufficient interest to demand notice is—

FLUORID OF SILICON, SiF_3 .

136. This substance, consisting, as its symbol indicates, of Fluorine and Silicon, may be produced in the form of a gas by heating in a flask a mixture of pulverized glass (which contains Silicic acid), and Fluorid of Calcium moistened with Sulphuric acid. As the gas is liberated Sulphate of Lime is formed.

An equivalent of Silicic acid, SiO_2 , three of Fluorid of Calcium, 3CaF , and three of Sulphuric acid, 3SO_4 , produce an equivalent of the gas, SiF_3 , and three of Sulphate of Lime, $3(\text{CaO}, \text{SO}_3)$.

If the SiF_3 is conducted into water by means of a glass tube terminating in Mercury, to prevent stoppage, and this covered with water, the invisible gas will be decomposed and Silicic acid re-formed.†

* The binary compounds of this group that contain O. are Oxacids. They are mostly of minor importance, but such as require notice will be attended to in their proper place.

† By the decomposition of the gas, there is produced beside, in solution, the double Fluorid of Hydrogen and Silicon, 2SiF_3 , 3HF , which, since it has

Of simple substances? What compounds are first noticed? What are *binary compounds*?

135. Why are the compounds containing Cl, Br, &c., first taken up? What in general are their names? What are those called that contain H. and why? What contain metals? The first binary compound noticed, its symbol, and composition?

136. How produced and in what form? Describe the chemical changes and the other product? What is the arrangement for a mutual decomposition between this gas and water, and what is re-formed?

This Silicic acid being in its *nascent* condition—that is, at the instant of its formation, combines with water and forms a starch-like Hydrate somewhat soluble in water.

Here then, we may have Silicic acid SiO_3 , which is usually a hard insoluble stone as seen in quartz and flint, brought to a soluble condition, a result which nature effects by other means perhaps, in case of the absorption of Silicic acid from the earth into the roots of grass-like plants, such as wheat, etc., and its transference to the stalks to render them sufficiently inflexible to stand erect.

III. 201. Fluorid of Si. and Hydrated Silicic acid formed.

THE HYDRACIDS.

137. The first of these to be noticed, BROMOHYDRIC ACID, HBr ., may be easily formed by putting firstly, a few drops of Br. into a test glass of water, and dropping in some grains of Phosphorus. Bromid of Phosphorus is formed, which is instantly decomposed, as the H. of the water takes the Br. from it to produce the HBr .

This latter substance may be converted into Bromid of Calcium and water, by dropping in chalk (Carbonate of Lime), the Carbonic acid being expelled with effervescence.

HBr . and CaO , CO_2 produce CaBr .,— CO_2 , and HO .

III. 202. Formation of Bromid of Phosphorus, Bromid of Hydrogen or Bromohydric acid, and Bromid of Calcium.

III. 203. Acid properties of HBr ., shown by means of litmus.

CHLOROHYDRIC ACID, HCl . *Eq.* $1+35.5=36.5$. *D.*, 1.25, *Air*, 1.

138. The Chlorid of Hydrogen is the most important of the Hydracids. It is thrown out by active volcanoes and is found at times dissolved in water in neighboring crevices.

It is produced in large quantities in the process of making Soda from Chlorid of Sodium, NaCl ., which begins by acting on NaCl . with Sulphuric acid, HO , SO_3 .

acid properties may be called Fluohydrosilicic acid. The changes are between 3 equivalents of Fluorid of Silicon, 3SiF and 3 of Water, $3\text{H}_2\text{O}$., producing Silicic acid, SiO_3 , and the double Fluorid, 2SiF_3 , 3HIF . This latter is a valuable test for Potassa.

What is meant by the *nascent condition*? Consequence of the presence of SiO_3 in water in its nascent state? Usual state of SiO_3 and examples? In what case and for what purpose is SiO_3 naturally rendered soluble?

137. First Hydracid noticed and its symbol? How formed? Three Bromids formed in 202? Acid properties of HBr . how shown, 203? Symbol composition and density of Chlorohydric acid? Equivalent and why?

138. Most important Hydracid? Natural source? HCl . is a product of what process?

It may also be formed by the direct combination of equal volume of its elements, Chlorine and Hydrogen.

A mixture of Cl. and H. kept in the dark, if the Cl. has never been exposed to light, remains a mixture, without chemical combination; but sunshine or flame causes instant and explosive union producing the same volume of Chlorid of Hydrogen.

139. HCl. is a powerfully pungent, colorless gas, though liquefiable by great pressure and very soluble in water. Pure ice cold water dissolves nearly 500 times its own volume of this gas.

140. The strong solution is intensely sour, changes litmus to red, is highly corrosive, and has general acid properties, whence it is called Chlorohydric acid.

It is decomposed by some metals, and metallic Oxyds, and by Carbonates, the metal replacing the H. so that a Chlorid of the metal is formed.

The gas does not support burning, and is highly poisonous in the lungs as the solution is in the stomach.

Ill. 204. A mixture of H. and Cl. exploded; the product gives a sour taste to water, and has an acid reaction on litmus.

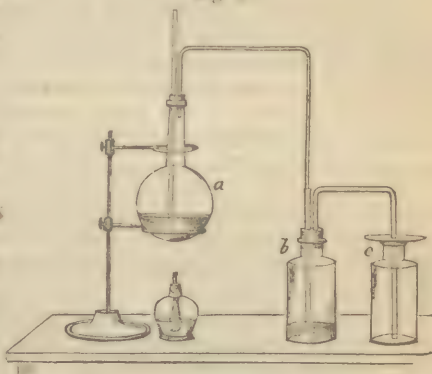
Ill. 205. Chlorid of Sodium, NaCl., acted on by Sulphuric acid, H_2SO_4 . An abundance of HCl. given off.

In this case Sulphate of Soda is formed, for NaCl., and H_2SO_4 , are equivalent to HCl., and $\text{Na}_2\text{O}, \text{SO}_3$.

Ill. 206. For obtaining HCl. from NaCl., &c., and for the collection or solution of the gas, an arrangement as in fig. 31 may be employed.

The flask (a), containing the NaCl. is provided with two tubes, one straight

Fig. 31.



Chlorohydric acid from common salt and water. The gas washed and collected.

How else formed? Mixture of H. and Cl. in the dark? Action of light?

139. Odor, color, and form of HCl.? Liquefiability? Quantity of the gas dissolved by water?

140. Strong solution of HCl. why called Chlorohydric acid? Is decomposed by what, and with what results? Action of HCl. on burning? On animals? Describe the results of exploding H. with Cl., 204? Of acting on NaCl. by H_2SO_4 , 205, and the chemical changes? Describe the apparatus (206) for collecting or dissolving HCl.?

for the introduction of the HO,SO_2 , the other bent for the escape of the gas which may be conducted through the water of the washing bottle (*b*), where any admixture of HO,SO_2 may be arrested. The gas then passes to a third vessel (*c*) full of air, for the collection of the gas, or filled with water when a solution is to be formed.

Ill. 207. When a flask is first filled with HCl . and its neck is then inverted in cold water, the water rushes violently into the flask, as it dissolves the gas.

Ill. 208. A taper extinguished in HCl .

Ill. 209. Zinc, Zn ., decomposes solution of HCl .; H . being evolved, and Chlorid of Zinc, ZnCl ., formed.

Ill. 210. Bicarbonate of Soda, $\text{NaO},\text{HO},2\text{CO}_2$., and HCl . in solution, suffer mutual decomposition; Carbonic acid, CO_2 ., being expelled with effervescence, and Chlorid of Sodium, NaCl ., and water, HO ., formed.

141. Where yeast or fermentation is not to be employed, the Bicarbonate of Soda (often termed Supercarbonate of Soda), and solution of Chlorohydric acid, are the best substances for making bread and cake light, provided care is taken to use such quantities as neutralize each other. As the product is common salt, none of that substance needs to be employed.

A strong solution of Chlorohydric acid gas in water, containing, in general, about forty per cent. of the gas, goes commonly by the name of Chlorohydric or Hydrochloric acid, and less properly is called Muriatic acid, and also Spirit of Salt.

This solution is very considerably used in preparing Chlorids, in the arts, and in medicine. Mixed with half its volume of Nitric acid, it constitutes nitro-muriatic acid, or *aqua regia*, which, on account of the large quantity of free Cl . in it, is a chemical solvent for Gold and Platinum, converting those metals into soluble Chlorids.

When pure, the solution of HCl . is colorless; but the commercial acid is generally of a yellowish color, on account of compounds of Iron and other impurities which it gains in the manufacturing process, and from which it may be separated by distillation.

142. When Chlorohydric acid gas and Ammonia gas, NH_3 ., are brought together, a dense cloud of Chlorid of Ammonium, NH_4Cl . (sal-ammoniac) is formed.

Like other Chlorids, Chlorohydric acid in solution gives, with Nitrate of Silver, AgO,NO_3 ., a white precipitate of Chlorid of Silver, AgCl .

The rapid solution of HCl ., 207? A taper how extinguished, 208? Reaction between HCl . and Zn ., 209? Bicarbonate of Soda and HCl ., 210?

141. Chemical substitute for yeast? Names of the strong solution of HCl ., and usual quantity of the gas present? Uses? What is nitro-muriatic acid? Uses, and why? Colors of solution of HCl ., and why?

142. Reaction between HCl and Ammonia? HCl . and AgO,NO_3 ?

III. 211. Cloud of Chlorid of Ammonium formed.

III. 212. Reaction between AgO, NO_2 and HCl .

FLUOHYDRIC ACID, HF .

143. This acid is produced by the reaction between common Sulphuric acid, $\text{H}_2\text{O}, \text{SO}_3$, and Fluorid of Calcium, CaF . (fluor spar). In its concentrated or anhydrous form, HF , is a most energetic and dangerous substance. In this, or in the hydrous condition, it has the singular property of corroding glass, and on this account is employed, as noticed in Article 25, for etching on that substance.

III. 213. A plate of glass etched by covering one side with wax, drawing the design or letters through the wax upon the glass, and then placing the plate as the cover to a leaden box, containing the Sulphuric acid, and the pulverized Fluorid of Calcium, CaF .

III. 214. Glass etched more quickly by covering with wax, &c., and then pouring on the liquid acid.

144. The formation of HF , is attended by the production of Sulphate of Lime, CaO, SO_3 ; since CaF and $\text{H}_2\text{O}, \text{SO}_3$ produce HF , and CaO, SO_3 .

The glass is decomposed on account of the strong attraction of F , for the Si , in the Silicic acid, SiO_2 , of the glass. In this decomposition, an equivalent of SiO_2 and three equivalents of $\text{HF} = \text{H}_3\text{F}_3$ produce Fluorid of Silicon (136), SiF_3 , and three equivalents of water, 3HO .

The remaining Hydracid, Iodohydric acid, HI , and the other non-metallic Iodids, Bromids, Chlorids, etc., do not require further attention.

THE HALOID SALTS.

145. A Haloid salt, as the name indicates from the Greek *hals*, salt, and *eidos*, form, is a salt which in its composition has a resemblance to Chlorid of Sodium, or common salt, NaCl .

A Haloid salt consists of two simple substances, one of which is a member of the Chlorine group, and the other a metal.

The most eminently typical of these salts are those of Potassium and Sodium. They are readily soluble in water.

III. 211 and 212? Symbol and composition of Fluohydric acid?

143. HF , how produced? Properties of HF ? Action on glass, and use? Etching how managed, 213? 214?

144. Explain the chemical changes in the formation of HF ? In the decomposition of glass? What Hydracid and other Iodids, &c., are undescribed?

145. What does a *Haloid* salt resemble, and whence take its name? It consists of what? The *Haloid* salts of K . and Na .?

146. IODID OF POTASSIUM, KI., consisting of Iodine, I., and Potassium, K., is an important artificial substance, crystallizing in white cubes, extensively employed in medicine, and somewhat as a reagent, giving characteristic precipitates. The brilliant red Iodid of mercury, produced by adding KI. to Chlorid of Mercury, has been referred to, in Ills. 18 and 199.

Ill. 215. Specimen of the crystals of KI.

Ill. 216. A fine but fugitive yellow Iodid of Lead, formed by the action of KI. on Acetate of Lead.

Ill. 217. A pale yellow Iodid of Silver, AgI., formed by the action of KI. on Nitrate of Silver, AgO, NO_3 , while Nitrate of Potassa, KO, NO_3 , remains in solution.

This AgI. is the substance formed on the Daguerreotype plate by the action of I. in coating the plate, and is afterward decomposed by light, being extremely sensitive to that agent.

147. CHLORID OF POTASSIUM. KCl., referred to, in Art. 28, as produced from Chlorate of Potassa in the process for obtaining O_2 , is a salt crystallizing in white cubes. It is found native at Vesuvius and some other localities, and is known mineralogically as *sylvine*.

Ill. 218. Specimen of KCl.

Ill. 219. Solution of KCl. and Nitrate of Silver give a white precipitate of Chlorid of Silver, AgCl., and leave KO, NO_3 in solution.

CHLORID OF SODIUM, NaCl. *Eq.* $23 + 35.5 = 58.5$. *D.* 2.25.

148. This important substance, known as common salt, and essential to animals and plants, is found in extensive beds. It is also the chief solid element of salt waters: 350 gallons of sea-water, at Nantucket, contain a bushel of NaCl.; while 30 to 35 gallons of the waters at Salina, New York, contain the same quantity.

NaCl. crystallizes in cubes, is volatile at high temperatures, and is soluble in 2.7 times its weight of water, being nearly equally soluble at all temperatures.

146. Name, symbol, composition, and importance, of the first noticed salt? Crystalline form and uses of KI.? Result of the reaction between KI. and Acetate of Lead, 216? KI. and Nitrate of Silver, 217? Relation of AgI. to the Daguerreotype process?

147. Symbol, production, natural source, and crystalline form, of Chlorid of Potassium? Reaction between KCl. and AgO, NO_3 ? Name, symbol, composition, and density, of Chlorid of Sodium? Equivalent how 58.5?

148. Importance and source of NaCl.? Quantity in sea-water and in the water of the Salina springs? Crystalline shape, volatility, and solubility, of NaCl.?

Besides its natural and culinary uses, it is employed to glaze earthen and stone ware, the Sodium in it combining with O. and the Silicic acid of the clay to form a glassy surface of Silicate of Soda.

NaCl. has been referred to (Art. 100) as the source of the different artificial and commercial preparations of Soda; also in Ill. 198, as the precipitant for Silver.

Ill. 220. Specimen of NaCl.

Ill. 221. Like other compounds of Na., common salt gives a yellow tinge to flame, as is shown by throwing it into burning alcohol. In this way, homogeneous yellow light is produced.

149. CHLORID OF BARIUM, BaCl., an artificial salt, is important as a test for Sulphuric acid. With the soluble Sulphates generally, it gives a white precipitate of Sulphate of Baryta, BaO,SO₃.

Ill. 222. Specimen of BaCl. in white tabular crystals.

Ill. 223. Sulphate of Soda, NaO,SO₃, and BaCl., give a precipitate of BaO,SO₃, and leave NaCl. in solution.

150. CHLORID OF CALCIUM, CaCl., is an artificial salt having a powerful tendency to *deliquesce*, that is, to absorb water and become liquid. It is therefore employed in practical Chemistry and in Photography as a *desiccator*, or drier of gases and of atmospheric air.

Ill. 224. CaCl. prepared in solution by the action of Chlorohydric acid, HCl., on marble (Carbonate of Lime, CaO,CO₂). Water, H₂O., is also formed, and Carbonic acid, CO₂, expelled.

The solution may be evaporated so as to crystallize. The crystals contain six equivalents of water; but when fused at a red heat, the water is expelled, and the solid cake formed on cooling being broken up, the salt is then in condition to be used as a desiccator.

151. FLUORID OF CALCIUM, CaF., known also as fluor and Derbyshire spar, is a tolerably abundant mineral, found in veins in other rocks, and in very small quantity in soils and sea-water.

CaF. has sometimes beautiful colors, as yellow, green, violet, red, and pink, and crystallizes in cubes and regular octahedrons. It is employed as the source of all the other compounds of Fluorine. When moderately heated, it is phosphorescent.

Uses? Effect of NaCl. (221) on the color of flame?

149. Symbol, source, and use, of Chlorid of Barium? Appearance, 222? Reaction between it and NaO,SO₃, 223?

150. Symbol and source of Chlorid of Calcium? What is *deliquescent*? A desiccator? What use of CaCl., and why? CaCl. how prepared, 224? How crystallized and rendered suitable for desiccation?

151. Symbol, names, and source, of Fluorid of Calcium? Colors and crystalline forms? Uses?

Ill. 225. Specimens of CaF .

Ill. 226. CaF gives a faint light in a dark room, if laid in powder on an iron plate heated below redness.

152. SESQUICHLORID OF IRON, Fe_2Cl_3 , a salt considerably used in medicine, may be prepared by the action of aqua regia on metallic Iron. It contains (as the Latin prefix, *Sesqui*, one and a half, indicates) equivalents, in the ratio of 3 to 2, or $1\frac{1}{2}$ to 1.

The MONIODID OF IRON, FeI , consisting of single equivalents of Iron and Iodine, as indicated by the prefix, *Mon*, from the Greek, *monos*, single, is also a medicinal preparation.

Ill. 226, a. Chlorid of Nickel, NiCl , and Chlorid of Cobalt, CoCl , having been prepared, in mixture, from commercial *zaffre*, containing Oxyds of these two metals, constitutes a sympathetic ink, which, by a moderate warmth, on holding the writing near a fire, is rendered anhydrous and *green*, but by cooling and exposure to air, becomes hydrous and colorless, if the ink has been sufficiently dilute.

Chlorid of Zinc, ZnCl , formed by dissolving Zn. in Chlorohydric acid, is employed to facilitate the adhesion of the metals in soldering.

153. The BICHLORID OF TIN, SnCl_2 , as the prefix, *Bi*, from the Latin, *bis*, twice, indicates, contains two equivalents of Cl, and one of Sn. It is employed as a mordant, or fixer of colors.

The PENTACHLORID OF ANTIMONY, SbCl_5 , and the TERCHLORID OF ARSENIC, AsCl_3 , are produced when these metals, in powder, are dropped into Cl. The use of the prefixes, *Penta*, Greek, *pente*, five, and Latin, *ter*, thrice, is readily understood.

Ill. 227 SbCl_5 , and AsCl_3 , formed by burning the metals in showers of fire in Cl.

154. The DICHLORID OF MERCURY,* Hg_2Cl_2 , or *calomel*, and the MONOCHLORID OF MERCURY, HgCl , or *corrosive sublimate*, are both white salts, though very unlike substances, the former being insoluble in water, and comparatively mild in its action on the animal system, the latter soluble, and very highly poisonous.

The poisonous properties of corrosive sublimate are partly, at least, due to its power of coagulating Albumin, and thus

* The prefix *Di*, is from the Greek, *dis*, twice; the equivalent of Hg_2 , being twice taken.

How made to phosphoresce, 226?

152. Symbol, composition, and use of Sesquichlorid of Iron? How prepared? Meaning and use of the prefix, *Sesqui*? Symbol, composition, and use of Moniodid of Iron? Derivation and use of the prefix, *Mon*?

153. Symbol of Bichlorid of Tin? Derivation and application of the prefix, *Bi*? Use of SnCl_2 ? What is a mordant? Symbols of the Pentachlorid of Antimony and Terchlorid of Arsenic? How produced? Derivation and meaning of *Penta*, and *Ter*? Phenomena attending the formation of SbCl_5 , and AsCl_3 , 227?

154. Symbol and common name of Dichlorid of Mercury? Monochlorid? Properties of the two Chlorids? Cause of the poisonous effects of HgCl .

arresting that continued chemical change, which is indispensable to animal life. It is employed to preserve the skins of birds and other animals, in collections in Natural History, and to preserve wood on the same account. It is the Albumin in skins, and in the sap of wood, that is the first to decay, and thus to institute those changes, that continue, under favorable circumstances, till the structure is wholly destroyed.

Eggs, which consist largely of albumen, are the most suitable antidote for poisoning by HgCl .

Ill. 228. Specimens of Hg_2Cl_2 , and HgCl .

Ill. 229. White of eggs coagulated by solution of HgCl .

155. The CHLORID OF SILVER, AgCl , is an abundant ore of Ag. in Chili. It is called horn silver by mineralogists, as it somewhat resembles horn in appearance. AgCl is precipitated whenever Ag., in solution, is acted upon by a Chlorid.

Ill. 230. Specimen of AgCl .

Ill. 230, *a.* Solutions of HCl and AgO, NO_5 precipitate AgCl , and leave Nitric acid, NO_5 in the water.

156. The SESQUICHLORID OF GOLD, Au_2Cl_3 , and the BICHLORID OF PLATINUM, PtCl_2 , are formed when these metals are chemically dissolved in *aqua regia*. In solution, the former is yellow and the latter is brownish red. These two chlorids are considerably employed in the arts, and in Practical Chemistry.

From the PtCl_2 , spongy platinum, Art. 83, is produced. All metallic Platinum goes through these forms.

Ill. 231. Specimens of Au_2Cl_3 , and PtCl_2 .

Having now sufficiently, though briefly, noticed the Chlorids, etc., it will be proper to next take up—

THE OXYDS.

157. An Oxyd, in the restricted sense, is a binary compound,

Of its preservative properties? Antidote? Distinguish Hg_2Cl_2 , from HgCl , 228? White of eggs how coagulated, 229?

155. Symbol, composition, and abundance of Chlorid of Silver? Why called horn silver? How precipitated? Reactions between HCl , and AgO, NO_5 , 230, *a.*?

156. Symbols of Sesquichlorid of Gold and Bichlorid of Platinum? How formed? Colors of the solutions? Uses of Au_2Cl_3 and PtCl_2 ? Distinguish Au_2Cl_3 from PtCl_2 ? What class of substances are noticed immediately after the binary compounds of the Chlorine group?

157. What is an Oxyd?

consisting of O. and some other simple, and destitute of acid properties.

The first Oxyd demanding attention is the—

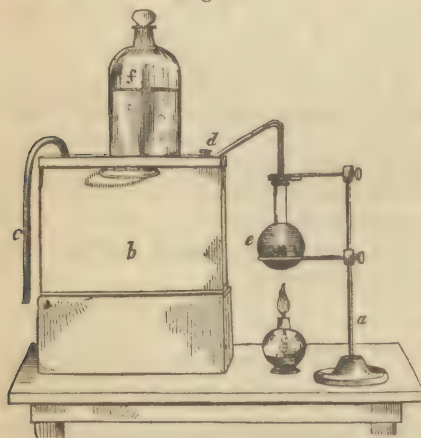
MONOXYD OF NITROGEN, NO. $Eq. 14+8=22$, *Dens.* 1.5, *Air*, 1.

158. This substance also called Protoxyd, i. e., the first Oxyd of Nitrogen (from the Greek, *protos*, first), is produced by heating Nitrate of Ammonia, NH_4O, NO_5 .

NO, is a sweetish, colorless, and transparent gas; liquefiable by pressure, and soluble in its own volume of water. It is readily decomposed by a flame, and then, furnishing a large share of O., supports burning almost as well as pure O.

When inhaled, on account of its solubility, it is taken up largely by the blood, transported to every part of the system, and by its richness in O., produces a powerfully stimulating or intoxicating effect, whence it is known as *exhilarating* or *laughing* gas.

Fig. 32.



Collection of Monoxyd of Nitrogen.

It should not be breathed over a minute, or two minutes at the utmost, and then, only by healthful persons, of moderate habits. Breathed too long it will cause sudden death.

Ill. 232. NO obtained from NH_4O, NO_5 , which is wholly resolved into NO, and water, HO, since $NH_4O, NO_5 = 2NO$, and 4HO.

Ill. 233. NO collected over water as in fig. 32.

Ill. 234. Taste and odor of NO, after being washed.

Ill. 235. Solution of NO not acid, since litmus is not reddened by it.

Ill. 236. A taper with incandescent wick, relights in NO.

Name, composition, symbol, and density of the first Oxyd noticed? Equivalent, why 22?

158. Other name for NO? How produced? Taste, color, form, liquefiability, and solubility of NO? How and why does it support burning? How does it produce its intoxicating effects, and how named in consequence? Caution? Chemical changes and products in the formation of NO, 232? Collection, 233? Its solution why non acid, 235? NO and a taper, 236?

II. 237. P. burns brilliantly in NO, forming Phosphoric acid, PO_5 .

III. 238. A mixture of equal volumes of NO and H. explodes violently, on the application of a flame, N. being liberated, and water, H_2O , formed.

There is one other Oxyd of Nitrogen, entitled most appropriately, the—

BINOXYD OF NITROGEN, NO_2 . *Eq.* $14 + 2 \times 8 = 30$.

159. This Oxyd is less significantly called the Deutoxyd, or second Oxyd of Nitrogen, from the Greek, *deuteros*, second.*

It is produced by the action of Cu. on Nitric acid, NO_3 ; and like the Monoxyd. is a colorless and liquefiable gas; but is very slightly soluble in water.

It is the most stable compound of N. and O, yet by a strong heat, it is decomposed, and will therefore abundantly yield O. to support the burning of a taper or of P. that is actively ignited. It does not explode with H. like the Monoxyd; the O. in it being held by a too powerful affinity to be instantly liberated, to unite with H.

NO_2 has so strong an affinity for O. that whenever exposed to contact with it, or with air, it becomes deep red, by rapidly absorbing and combining with O. to form Nitrous acid, NO_3 or Hyponitric acid, NO_4 , which substances, in the form of vapor, have a suffocating odor and a reddish color. The taste and odor of NO_2 , can therefore, never be known.

160. These two Oxyds of Nitrogen, like the two Chlorids of Mercury already described, strikingly illustrate the chemical principle, that the same elements, by combining in different ratios, may form substances of very diverse and even opposite properties; for while NO. is agreeable to inhale, NO_2 is suffocating; NO. is explodable with H, NO_2 is not; NO. is unaffected by air, NO_2 is instantly changed; NO. is very soluble in water, and NO_2 but slightly soluble.

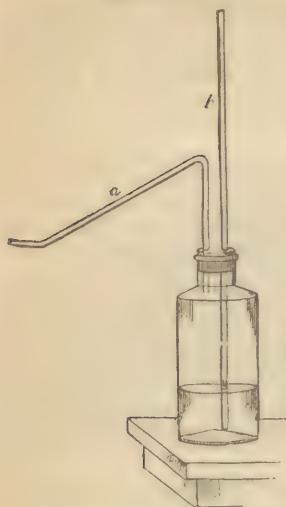
* The terms Binoxyd and Deutoxyd are not synonymous, the former signifying, literally, an Oxyd in which the equivalent of O. is doubled, while the latter signifies merely the second Oxyd, which in some cases may happen to be a Binoxyd. The terms Protoxyd and Deutoxyd are not sufficiently definite, and should go out of use.

NO. and P, 237? And H, 238? How many oxyds of N. are there? Symbol, equivalent, and density of the Binoxyd?

159. Other name? How produced? Form, color, liquefiability, and solubility of NO_2 ? Stability? How and why does it support burning? Why can not a mixture of NO_2 and H. be exploded? Action of air or O. on NO_2 ? Why can not the taste and odor of NO_2 be known?

160. What chemical principle is illustrated by NO. and NO_2 ? In what respects do NO. and NO_2 differ?

Fig. 32, a.



Arrangement for producing Binoxid of Nitrogen.

substances when P. is burned under water by forcing upon it a stream of O. It is a brownish insoluble solid.

Ill. 245. P_2O formed.

OXYD OF CARBON, or Carbonic Oxyd, CO, is a colorless, inflammable gas to be hereafter noticed.

There are two Oxyds of Hydrogen, the Monoxyd and the Binoxyd.

MONOXYD OF HYDROGEN, HO. *Eq.* $1+8=9$. *Density*, 1.

162. This is common water, a very abundant substance in nature, continually subject to decomposition, as in the formation of certain vegetable substances, but as constantly reproduced in the processes of combustion, respiration, and organic decay. It

Ill. 239. NO_2 obtained from NO_5 , by the action of Cu; Nitrate of Copper, CuO, NO_5 produced; $4NO_5$ and $3Cu$, giving NO_2 and $3(CuO, NO_5)$. The Cu. in chips may be placed in a bottle arranged with two tubes (as in fig. 32, a), one straight for the introduction of the acid; the other bent for the delivery of the gas.

Ill. 240. A faint flame extinguished, in NO_2 .

Ill. 241. P. strongly ignited, burns brilliantly in NO_2 ; Phosphoric acid, PO_5 formed.

Ill. 242. A mixture of equal volumes of NO_2 and H. does not, like that of NO. and H., explode, but burns moderately.

Ill. 243. A bell glass on the shelf of the pneumatic trough, being partly filled with NO_2 , the stopper is taken out for an instant, air enters, the water falls in the bell, a deep red vapor is produced, which, being absorbed by water, fades away and the water rises in the bell.

Ill. 244. NO_2 , thrown out into the air, produces a dense cloud of brownish red vapor.

161. OXYD OF PHOSPHORUS.

P_2O , is produced along with other

Name the chemical changes and products in forming NO_2 from NO_5 , 239? Action of NO_2 on flame, 240? On fully ignited P, 241? Combustion of H. with NO_2 , 242? Air on NO_2 , 243? 244?

161. Symbol, composition and production of Oxyd of Phosphorus? What is said of Carbonic Oxyd? How many and what Oxyds of H. are there? Symb. equiv. and density of Monoxyd of Hydrogen?

162. Chemical name for water? Abundance? Decomposition and reformation?

is universally an animal and vegetable element, and is often present in rocks, as in common gypsum.

Water consists of an equivalent, or eight parts by weight of O. and one equiv. or one part of H. Since, however, O. is 16 times heavier than H. there is by volume, twice as much H. as O. in water.

It was mentioned (78) that a gallon of water contains 1306.88 gallons of H. As the same water contains half as much, *i. e.*, 653.44 gallons of O. there are altogether 1960.32 gallons of gas in one gallon of water therefore;

When water is decomposed entirely into gas, it increases in volume nearly 2000 times; since a gallon of water contains almost 2000 gallons of the two gases.

Ill. 246. Moisture produced by burning or breathing, condenses on a cold glass.

Ill. 247. When pulverized gypsum is heated in a flask, moisture arises and condenses in the neck.

163. Water freezes at 32° , and boils under a mean atmospheric pressure at 212° , but when that pressure is removed, at about 60° .

It is denser at 39° than at any other temperature, expanding if either heated or cooled from that point. Ice floats on water since its sp. gr. is .94.

A cubic inch of water at 60° weighs nearly $252\frac{1}{2}$ grains.

Ill. 248. Water contracts, and afterward expands, in being cooled from 60° to 32° .

Ill. 249. Water boiled at 60° in a closed flask containing no air, by the application of ice, which keeps the vapor condensed, and thus removes its pressure.

164. Water is remarkable for its solvent powers, being capable, under favorable circumstances, of dissolving portions of a great variety of substances.

The solution of substances in water, is a simple solution in most cases, there being no chemical change, and no development of new properties.

Ill. 250. Sudden absorption of Ammonia gas by cold water.

Composition of water by weight and by bulk? [Number of gallons of O? and of H. in one gallon of water and how?] Increase in volume when water is decomposed and why? How is it shown that HO. is produced by burning or breathing, 246? That mineral gypsum contains HO, 247?

163. Freezing point of HO? Boiling point with and without atmospheric pressure? At what temperature is HO. densest? Effect of either heating or cooling HO. from 39° ? Why does ice float? Weight of a cubic inch of HO? What occurs in cooling HO. from 60° to 32° , 248? In what way is HO. boiled at 60° , 249?

164. Solvent powers of HO? Kind of solution effected in HO? What gas is suddenly dissolved in HO, in 250° ?

Ill. 251. Solution of Bichromate of Potassa, $\text{K}_2\text{Cr}_2\text{O}_7$, by which water acquires, in part, the color and properties of the salt.

Some substances dissolve or mingle with water in all proportions, as alcohol and the hydrous liquid acids, for example; but in general there is a limit to the quantity of a substance which water can dissolve, although this limit is, in most cases, affected by temperature.

Gases are more soluble in cold water than in hot; while solids are chiefly, most soluble in hot water; but to this there are exceptions, as Lime is most readily dissolved by cold water, common salt is about equally soluble at all temperatures, and dry Sulphate of Soda dissolves best at 93° .

Hence it follows that if the solution of a gas in water be heated, a portion of the gas will be expelled; and cooling the solution of a solid will, in many cases, cause a portion of the solid to separate and crystalize.

Ill. 252. Gas expelled from solutions of Ammonia, NH_3 , and of Chlorohydric acid, HCl , by heat.

The escape of the HCl is evident, since combining with the moisture of the air it forms a cloud. That of the NH_3 is only seen by the effervescence in the flask, or when brought in contact with the escaping HCl to form a cloud of Chlorid of Ammonium.

Ill. 253. A strong solution of Nitrate of Ammonia, being cooled, the salt crystalizes.

Crystals sometimes contain a definite amount of water which is necessary to their formation, and this is called *water of crystallization*. In case the water of crystallization passes off, by exposure of the crystals to air, they fall into a dry floury powder, and are then said to *effloresce*.

Ill. 254. Specimen of crystals of Sulphate of Soda, containing water of crystallization. Also, specimen of the effloresced crystals.

165. Owing to its solvent powers, water is never naturally pure, always containing dissolved some portion of most of the substances with which it has come in contact.

Effect of dissolving Bichromate of Potassa in H_2O , 251? What substances mingle with water in all proportions? What is said of a limit in solution and of the effect of temperature? The solution of gases? Of solids? Exceptions? Effect of heating the aqueous solution of a gas? Of cooling in some cases the hot solution of a solid? What gases are expelled in 252 from aqueous solution and how is this made evident? What solid crystalizes in 253, from a cooling hot solution? Water of crystallization? Efflorescence? What salt is exhibited in 254, containing water of crystallization and again effloresced?

165. Why is natural H_2O never pure?

From these impurities, it is separated by repeated distillation. Distilled water is insipid, since it is the Carbonic acid and the salts in spring or well water that give it taste.

Ill. 255. The distillation of water; or water boiled and its steam condensed again, in a separate cold vessel, to the liquid form.

The purest natural water is rain water, caught in clean vessels in the open country; but this contains some air and Carbonic acid. The water of springs and streams in mountainous regions, in general has had less opportunity to dissolve impurities; as the extensive washing of these districts by rains has exhausted, in a degree, the soluble substances.

166. The respiration of fishes is carried on by means of the air naturally dissolved in water; and since O. is more soluble than N, the air which water contains dissolved, is richer in O. than atmospheric air.

Fish soon die, if put into cold water that has just been boiled to expel the air; and they are never found in very elevated lakes as in some of those in Switzerland, and the Alps; since on account of the diminished atmospheric pressure, there is little air dissolved in their waters.

Ill. 256. Water, subjected to the vacuum of an air pump, gives off an abundance of air bubbles.

Ill. 257. When water is heated in a glass vessel, bubbles of air appear within the mass, and come to the surface.

Water, impure on account of dissolved fetid gases, is purified by filtration through *fresh* charcoal, which absorbs the gases and leaves the water sweet.

Ill. 258. Putrid rain water sweetened by means of charcoal.

167. The impurities which water contains may always be detected and separated by proper reagents.

Where the quantity of foreign matter in natural water is large, it is called “*mineral water*.” N. is abundant in some springs, as those of Lebanon, N. Y. Carbonic acid, principally, causes the Saratoga spring waters to effervesce.

Sulphur waters are those that contain Sulphuretted Hydro-

How purified? Taste of distilled HO? Cause of the taste of other waters? Explain the distillation of water, 255? Purest natural waters and why?

166. Respiration of fishes? Quality of the air which water contains dissolved? Fish in cold but recently boiled water? In elevated lakes? How is air expelled from water, in 256? 257? How is HO. purified from fetid gases? Operation on putrid water, 258?

167. Detection of impurities in HO? Mineral water? Mention waters that contain N.? Carbonic acid? Sulphur waters?

gen. When Iron is present, the water is said to be *ferruginous* or *chalybeate*.

Ill. 259. Sulphur water blackens silver and metallic solutions, by forming Sulphurets of the metals.

Ill. 260. Water containing Iron gives, with Ferrocyanid of Potassium, a blue precipitate of Ferrocyanid of Iron.

168. The purest water for general use, is the most healthful. The commonest impurities in water are Lime, Chlorids, and Sulphates. These, and especially Lime, render water “hard;” so that common soap is decomposed and an insoluble adhesive Lime soap formed, and this prevents rather than facilitates cleansing. Rain water is soft, because free from these impurities.

Ill. 261. Contrast between soft and hard water in respect to the presence of Lime, as shown by its test, the Oxalate of Ammonia. From the hard water, Oxalate of Lime precipitates.

Ill. 262. Rain water is free from Chlorids, but these are more or less abundant in well water, as shown by the test, Nitrate of Silver producing a precipitation of Chlorid of Silver.

Ill. 263. The Chlorid of Barium causes no precipitation in rain water, but generally shows the presence of Sulphates in well water, by the formation of Sulphate of Baryta.

Ill. 264. An alcoholic solution of soap remains transparent in rain water, but forms a white insoluble Lime soap in hard water.

169. Water has an energetic attraction for many substances. Its combinations are generally called *Hydrates*.

Substances, which are combined with it, are said to be in their hydrous condition; and *anhydrous*, when free from it.

The combination of water with the Lime with which a ship is loaded may, in case of leakage, fire the ship.

Ill. 265. Lime, CaO , combines with water, slakes and forms Hydrate of Lime, CaO.HO , developing, at the same time, a large amount of heat.

Ill. 266. Common hydrous Sulphuric acid, HO.SO_3 , combines with more water, and produces heat sufficient to boil Ether, and water even, when large quantities are used.

What are chalybeate waters? Action of “Sulphur water,” 259? Detection of Iron, 260?

168. Most healthful water? Commonest impurities? Cause of “hard water”? Hard water and soap? Rain water why soft? Presence of Lime in hard water, how shown, 261? Chlorids, how detected in most well water, 262? Sulphates, 263? Action of hard and soft water on soap, 264?

169. Affinities of water? Hydrates? The hydrous condition? The anhydrous? Cause of the production of heat by the action of HO ? Formation of Hydrate of Lime, 265? Combination of Sulphuric acid with water, 266?

170. BINOXYD OF HYDROGEN, HO_2 , is a colorless, corrosive, and poisonous artificial substance, and hence curious; but is of little importance.

There are no other non-metallic Oxyds requiring notice. In the next place, we may take up

THE ALKALINE OXYDS.

171. The Monoxys of the seven metals, Potassium, Sodium, Lithium, Barium, Strontium, Calcium, and Magnesium, are named by merely changing the termination, *um*, to *a*. Thus, the Monoxyd of Potassium, KO , is called Potassa, and the names and symbols of the others are, respectively, Soda, NaO ; Lithia, LO ; Baryta, BaO ; Strontia, SrO ; Lime, CaO ; and Magnesia, MgO .

The Monoxyd of Calcium, CaO , having so long been known as Lime, its name remains an exception to the general rule.

The alkaline properties and native condition of these Oxyds, were referred to, in Arts. 95 to 112 inclusive. One or two of them require further notice.

172. POTASSA, KO , *Eq.* $39+8=47$, has a very energetic attraction for water, and is seldom seen except in form of the Hydrate, KO, HO , which is powerfully caustic, and is used in surgery, practical Chemistry, and for other purposes.

III. 267. When K. is thrown on water, and the KO , which is formed, becomes sufficiently cool, it combines with the water explosively.

173. SODA, NaO , *Eq.* $23+8=31$, is like KO , very caustic, attracts water strongly to form a Hydrate, and dissolves largely in water.

LIME, CaO , *Eq.* $20+8=28$, is obtained by heating limestone in kilns, by which the Carbonic acid is expelled.

An *Eq.* of CaO , 28 parts by weight, combines, in slaking with an *Eq.* of water, 9 parts, to form the Hydrate, CaO, HO .

170. Composition, symbol, color, properties, &c., of Binoxyd of Hydrogen? Other non-metallic Oxyds? What class of substances are next in order?

171. How are the Monoxys of the metals of the Potassium group, named? Give the names and symbols of these seven Oxyds? Alkaline properties and natural conditions?

172. Composition, symbol, and equivalent of Potassa? Its attraction for water? Most usual, artificial state? Uses? Combination of KO , with water, 267?

173. Composition, symbol, equivalent and properties of Soda? Composition, symbol, and equivalent of Lime? How is CaO , obtained?

The water should not be employed, especially if cold, in larger quantity, as the materials would be chilled, and the slaking but imperfectly performed.

The Hydrate, diffused in large quantity through water, forms the *milk of Lime*, and, dissolved in water, constitutes Lime water, which, when a cold saturated solution, contains one grain of CaO , to 778 of HO .

By exposure to air, Lime is said to air slake, passing gradually to a Hydrate, and then becoming Carbonated by absorbing Carbonic acid from the air.

The hardening of the Lime, in *mortar*, depends partly, at least, on its power to absorb Carbonic acid. Lime for *hydraulic cement*, capable of hardening under water, is obtained from limestone containing Magnesia, Oxyd of Iron, and other substances; and it is to the presence of these with the Lime, that this peculiarity is due. (See appendix.)

Ill. 268. A transparent, cold saturated solution of Lime becomes turbid when heated, from a partial precipitation; proving that Lime is less soluble in hot water.

MAGNESIA, MgO , is a white powder, the *calcined magnesia* of the shops; and, as noticed in Art. 111, is abundant in certain rocks.

Ill. 268, α . Solutions of KO , NaO , BaO , CaO , and MgO , like all the Monoxys of this group, have an alkaline action on litmus, red cabbage, and turmeric water.

THE EARTHY OXYDS.

174. ALUMINA, Al_2O_3 , is the *Sesquioxyd of Aluminum*. It is, as chemically prepared, a white insoluble powder, without the alkaline reaction possessed by the Oxyds of the previous group. It is a large element in almost all rocks but the pure limestones (Art. 115).

Alumina is not a strong base; its salts often have an acid reaction, and are decomposed with facility. Indeed, Al_2O_3 sometimes acts the part of an acid in combining with bases, as in the Aluminate of Potassa, $\text{KO}, \text{Al}_2\text{O}_3$.

Al_2O_3 is remarkable for its attraction for organic substances,

Quantity of HO , that combines with CaO , and that should be employed in slaking? Milk of Lime? Lime water? The air slaking of CaO ? Why does mortar harden? What substances give to *hydraulic cement* the power of hardening under water? How shown, 268, that CaO is most soluble in cold water? Composition, symbol, appearance, and abundance of Magnesia? Next class of binary compounds?

174. Names, composition, and symbol of the first earthy Oxyd? Its appearance and properties? Al_2O_3 , and rocks? Basic properties? Acid, and example? For what organic substances has Al_2O_3 a strong attraction?

such as coloring matters, and that substance which constitutes the fibre of cotton. Its mutual attraction for these, gives it the properties of a *mordant*.

By combining Al_2O_3 with organic colored substances, and precipitating them, insoluble compounds, known as *lakes*, are formed.

Carmin is a lake consisting chiefly of Al_2O_3 , and the coloring principle of the *cochineal* insect. Salts containing Al_2O_3 are extensively employed in dyeing.

III. 269. The coloring matter of cochineal, alkanet, turmeric, &c., precipitated from solution by adding Sulphate of Alumina and Potassa (alum), and then solution of Potassa.

175. The earthy Oxyds, Glucina, G_2O_3 ; Yttria, YO ; Thoria, ThO ; Zirconia, Zr_2O_3 ; as well as the Oxyds of Cerium and Lanthanum, are very rare and comparatively unimportant.

Such remaining metallic Oxyds as demand attention will next be noticed.

176. BINOXYD OF MANGANESE. MnO_2 , is the only important natural condition of Mn, and, as has already been noticed, is used for a variety of purposes, among others, in glass-making and staining.

177. The following are the compounds of Iron and Oxygen:—

1. Monoxyd of Iron,	FeO .
2. Blackoxyd “	Fe_3O_4 .
3. Sesquiöxyd “	Fe_2O_3 .
4. Ferric Acid,	FeO_3 .

MONOXYD OF IRON, FeO , is a powerful salifiable base, existing only in combination with acids, and being incapable of isolation.

The Sulphate of Iron, FeO,SO_3 , known as green vitriol, and the Carbonate of Iron, FeO,CO_2 , contain it.

III. 270. Specimens of FeO,SO_3 and FeO,CO_2 .

178. BLACK OXYD OF IRON, Fe_3O_4 , is an abundant and valuable ore. It is susceptible of magnetism, whence it is called,

Why a mordant? *Lakes* how formed? What is *carmin*? Uses of the salts of Al_2O_3 ? Precipitation of coloring matters, 269?

175. Names, symbols, and importance of the other earthy Oxyds? Oxyds next noticed?

176. Symbol and composition of Binoxyd of Manganese? What is said of MnO_2 ?

177. Names and symbols of the compounds of Iron with O? Basic properties of FeO ? Isolation? Contained in what salts? Distinguish between the specimens, 270?

178. Symbol, composition, abundance, and use, of Black Oxyd of Iron?

in Mineralogy, *magnetite*. It is sometimes naturally magnetic in a high degree, and it is then known as *lodestone*.

It is often abundant in sand, from which it is separated by a magnet, and then constitutes common black sand, used as an article of stationery.

It is not a salifiable base, and indeed may be regarded as itself a salt, consisting of FeO . and Fe_2O_3 .

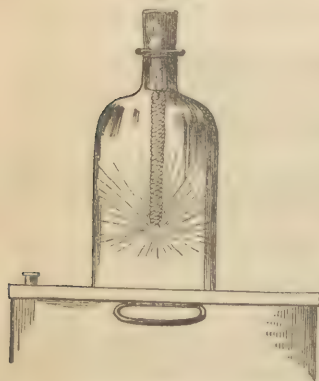
This black Oxyd is formed indirectly by burning Iron wire in O. The melted Sesquiöxyd, which is the direct product, loses some of its O. by means of the high temperature, and becomes Fe_3O_4 .

179. The SESQUIÖXYD OF IRON, Fe_2O_3 , is also a very abundant and valuable ore, both in the anhydrous and hydrous condition.

It is not a strong base, and acts sometimes the part of an acid. It constitutes common Iron rust.

Prepared in fine powder by chemical process, it is known as *rouge*, and *colcothar*, and is used in polishing metals, especially Daguerreotype plates.

Fig. 33.



Iron burning in Oxygen.

Fe_2O_3 gives the color to *red chalk* and the ochres. Most colored rocks owe their color, more or less, to some Oxyd of Iron.

III. 271. Specimens of Fe_3O_4 , Fe_2O_3 , ochre, rouge, and red chalk.

III. 272. Fe. burned in O. (fig. 33); Fe_2O_3 and Fe_3O_4 formed.

The Hydrated Sesquiöxyd, $\text{Fe}_2\text{O}_3 \cdot 3\text{HO}$, is the best antidote to poisoning by Arsenious acid (ratsbane). It should be prepared for the occasion, if possible, as it is most active when fresh. It acts by converting the poison into an insoluble Arseniate of Iron.

III. 273. Precipitation of $\text{Fe}_2\text{O}_3 \cdot 3\text{HO}$. from an Iron salt by an alkaline solution.*

* See *Acidum Arseniosum* in the United States Dispensatory.

Magnetite? Lodestone? Black sand? Basic properties? Formation? 179. Composition, symbol, and abundance, of Sesquiöxyd of Iron? Conditions? Iron rust? Rouge, colcothar, and uses? Red chalk and ochre? Colored rocks? Name the different specimens, 271? Explain the burning of Iron, 272? Antidote to poisoning by "arsenic" or "ratsbane," and why? Precipitation of $\text{Fe}_2\text{O}_3 \cdot 3\text{HO}$, 273?

180. Of the different compounds of Fe. and O, that which has least O, the Monoxyd, FeO , is the strongest base, and completely neutralizes acids.

That having the most O, Ferric acid, FeO_3 , has decided acid properties. The others are either neutral, as Fe_3O_4 , or indifferent, as Fe_2O_3 .

The same principle applies generally to metallic Oxyds: that is, the Oxyd having the least O. is the strongest base; that having the most, is acid; and the intermediate Oxyds are neutral or indifferent.

181. SESQUIÖXYD OF CHROMIUM, Cr_2O_3 , combines with acids to form emerald and purple salts. It constitutes the paint known as *chrome green*.

Ill. 273. Specimen of chrome green as a dry powder.

The OXYD OF ZINC, ZnO , formed by burning Zn, is a very superior white paint. ZnO , colored red by scales of Fe_2O_3 , is known as *red zinc ore*.

Ill. 274. Zn. burned in O; ZnO . formed.

Ill. 275. Specimen of ZnO . as a fine white powder.

Ill. 276. Specimen of red Zinc ore.

182. MONOXYD OF LEAD, PbO , is known as *litharge*. It is used in mixing paints, as a drier; also in glass-making, since it is capable of combining with large quantities of Silicic acid. PbO . is the base of several salts.

RED OXYD OF LEAD, Pb_3O_4 , is used in glass-making, and as a paint, under the name of *red lead*. The composition of the commercial article is variable. It may be employed, instead of MnO_2 , for obtaining Chlorine.

Ill. 277. Specimens of PbO . and Pb_3O_4 .

DINOXYD OF LEAD, Pb_2O . The prefix in the name of this, from the Greek *dis*, double, indicates two equivalents of the

180. Basic and acid properties of the different compounds of Iron and O? General principle in respect to metallic Oxyds?

181. Symbol of Sesquiöxyd of Chromium? Color of its salts? Chrome green? Appearance of Cr_2O_3 , 273? Symbol, formation, and use, of Oxyd of Zinc? Red Zinc ore? When Zn. is burned in O. (274), what is the product? Appearance of ZnO , 275?

182. Symbol, common name, uses, and why, of the Monoxyd of Lead? PbO . as a base? Symbol, uses, and common name, of Red Oxyd of Lead? Obtaining Cl.? Distinguish the specimens, 277? Symbol of Dinöxyd of Lead? Prefix?

metal to one of O. Pb_2O is probably the coating that forms over the surface of Lead exposed to air.

183. DINOXYD OF COPPER, Cu_2O , is an important ore of the metal, known as *red Copper*. It gives a red color to glass, and is used in glass-staining.

Ill. 278. Specimen of red Copper.

MONOXYD OF COPPER, CuO , is found native, and is prepared artificially as a black powder for use in the analysis of organic substances.

Its Hydrate, CuO.HO , is a fine blue powder. Both the Oxys of Cu. are salifiable bases.

Ill. 279. Specimen of CuO .

Ill. 280. CuO.HO , precipitated from Sulphate of Copper by solution of Potassa.

The Oxys of the remaining metals of the third group, Nickel, Cobalt, Cadmium, and Uranium, are comparatively unimportant.

184. BINOXYD OF TIN, SnO_2 , is an abundant ore, and the source of the metal.

It may be produced in the hydrated condition, as a white powder, by the action of Nitric acid on the metal. It is used for polishing, under the name of *Tin putty*. With glass, it forms a white enamel.

Ill. 281. Formation of the hydrated Binoxid of Tin.

V, W, Mo, Ta, Ti, Bi, Sb, As, and Os, the other metals of the group to which Sn. belongs, do not form Oxys of sufficient importance to require notice.

185. MONOXYD OF MERCURY, HgO , may be prepared by heating Hg. in contact with air for a long time just below its boiling point. It is then seen in solid red scales.

It may be produced by the action of KO. on a solution of

Coating on Lead surfaces?

183. Symbol, importance, mineralogical name, and use, of Dinoxid of Copper? Select the specimens, 278? Symbol, sources, appearance, and use, of Monoxid of Cu? Its Hydrate? Basic properties? Select the specimen, 279? CuO.HO , how precipitated, 280? Oxys of remaining metals of group 3?

184. Symbol, abundance, and use, of Binoxid of Tin? How produced as a Hydrate? Tin putty? White enamel? Remaining metals of group 4, and their Oxys?

185. Symbol, preparation, and appearance, of Monoxid of Mercury?

Chlorid of Mercury, HgCl , and in other ways. It is a pharmaceutical preparation, known commonly as *red precipitate*.

Ill. 282. Specimen of HgO . in crystalline scales.

Ill. 283. HgO . from HgCl . by means of KO .

Having noticed the composition, uses, etc., of the most important Oxyds, the binary compounds next in order are

THE SULPHURETS.

186. A sulphuret is a compound consisting of Sulphur and another simple. The first of these which deserves notice is

BISULPHURET OF CARBON, CS_2 . This substance is formed by dropping S. into a retort containing red-hot charcoal.

CS_2 is a fetid, volatile, combustile liquid, boiling at 110° .

It is remarkable for its power of refracting light, and as a solvent for Iodine, Sulphur, Phosphorus, gutta percha, and India rubber.

Ill. 284. Specimen of CS_2 .

Ill. 285. CS_2 burned with a pale blue light, and the formation of Carbonic and Sulphurous acids.

There are two Sulphurets of Hydrogen, HS . and HS_2 . The latter is not important.

187. MONOSULPHURET OF HYDROGEN, HS . *Eq.* $1+16=17$. *D.* 1.19; *air*, 1. This substance is also called *Sulphydric acid*, since it possesses acid properties. It is less appropriately named Hydro-sulphuric acid and Sulphuretted hydrogen.

It is an abundant natural product, being thrown out by volcanoes and Sulphur springs, and produced by the decomposition of substances containing S.

HS . is formed artificially by the action of Sulphuric acid, HO, SO_3 , on the Monosulphuret of Iron, FeS , or by means of the reaction between Sulphuret of Antimony, SbS_3 , and Chlorohydric acid, HCl .

HS . is a fetid, colorless, acid gas, liquefiable and solidifiable

Common name? Select the specimen of HgO , 282? HgO , how formed in 283? What class of substances follow the Oxyds?

186. What is a Sulphuret? Name, symbol, and formation, of the first Sulphuret noticed? Odor, form, combustibility, and boiling point, of CS_2 ? Remarkable for what? Phenomena, etc., of its combustion? Sulphurets of H?

187. Symbol, equivalent, and density, of Monosulphuret of H? Other names? Natural sources? Artificial formation? Odor, color, and form, of HS ? Liquefiability, solidifiability, and solubility?

by cold and pressure, and soluble in about one third its volume of pure, ice-cold water.

Ill. 286. H_2S . obtained from Sb_2S_3 and HCl ; the products being H_2S . and SbCl_3 . The gas collected over water.

Ill. 287. In the solution of H_2S . in cold water, if the process is managed as in *Ill.* 30, with Cl_2 , the bottle in which the solution is made may be held to the hand, as in *fig. 34*, by atmospheric pressure.

Fig. 34.



Production of a partial Vacuum by the Solution of Sulphydric Acid Gas.

188. H_2S . is combustile, forming, when burned, water, HO , and Sulphurous acid, SO_2 . It explodes with $1\frac{1}{2}$ times its volume of O .

Ill. 288. H_2S . burned with a pale blue flame, and, the supply of air being limited, with a deposite of S .

Ill. 289. H_2S . exploded with O .

H_2S . is remarkable for the readiness with which it may be decomposed to furnish S . to combine with metals, converting them into Sulphurets, which are insoluble. On this account it is a valuable reagent in chemical analysis, and is very frequently used to precipitate metals from solution.

Ill. 290. Solutions of Cu , Pb , Fe , and As , give, with H_2S , dark precipitates, except the As , which with it forms a yellow.

Ill. 291. An instantaneous picture, produced by projecting H_2S . on a moist drawing, made with Acetate of Lead.

189. The moderate drinking of Sulphur waters is considered healthful. Their medical properties are partly owing to the presence of H_2S . The gas is highly poisonous when inhaled, or when largely absorbed through the skin. $\frac{1}{1500}$ of it in the air is sufficient to kill a bird.

White Lead paint should not be used in those parts of buildings where H_2S . abounds, as the H_2S . converts the Lead into a dark Sulphuret.

The sulphurets of the metals of the Potassium and Aluminum

Chemical changes and products in obtaining H_2S . from Sb_2S_3 and HCl ? Describe the solution of H_2S , and state why the bottle is held to the hand?

188. Combustibility of H_2S , products when it is burned, and their symbols? Explosion? Phenomena of the burning of H_2S , 288? Remarkable action of H_2S . on metals? Use on this account? Action of H_2S . on solutions containing Cu , Pb , Fe , and As , 290? Instantaneous picture how produced, 291?

189. Drinking Sulphur waters? Medicinal properties? Poisonous properties of H_2S ? White Lead paint? Importance of Sulphurets of K , Al , Fe , Zn , &c.

groups do not require attention. Those of Fe, Zn, Pb, and Cu, are more important.

190. MONOSULPHURET OF IRON, FeS , is a blackish substance prepared by fusing its elements together. It is used in the laboratory, as just noticed, for the preparation of HS .

BISULPHURET OF IRON, FeS_2 , is abundant in nature.

It crystalizes in two distinct forms; one of which is commonly the cube. This variety has a bronze yellow color, and is known as Iron *pyrites*, also as *fool's gold*, since it is often mistaken by ignorant persons for gold.

Unlike that valuable metal, it is very brittle, gives a strong odor of S. when heated, and becomes susceptible to the magnet, so that it is very easily distinguished.

The other variety, called *marcasite*, is of a lighter color.

MAGNETIC SULPHURET OF IRON, Fe_7S_8 , is also an abundant mineral.

The natural Sulphurets of Iron are employed for the extraction of S, and the manufacture of Sulphuric acid.

III. 292. Specimens of Sulphurets of Iron.

III. 293. Iron pyrites loses S, and becomes susceptible to the magnet, by being heated.

SULPHURET OF ZINC, ZnS , is a valuable ore of the metal, known as *Zinc blende*.

III. 294. Specimens of ZnS .

191. SULPHURET OF LEAD, PbS , known as *galena*, is the only valuable ore of Lead. It crystalizes in cubes and allied forms, has a splendid metallic lustre, and a density of about $7\frac{1}{2}$.

III. 295. Specimen of PbS .

DISULPHURET OF COPPER, Cu_2S , is known, when an independent mineral, as Copper glance. It exists in combination in

190. Symbol, appearance, preparation, and use of Monsulphuret of Iron? Symbol and abundance of the Bisulphuret? Crystalline form? Color and name of the variety crystalizing in cubes? Fool's Gold? How does it differ from Gold? Symbol and abundance of the Magnetic Sulphuret of Iron? Uses of the natural Sulphurets of Iron? Name and distinguish the different specimens of Sulphurets of Iron, 292? Effect of heat on Iron pyrites, 293? Symbol and use of Sulphuret of Zinc? Select the specimen, 294?

191. Symbol, common name, and use of Sulphuret of Lead? Crystalline form, lustre, and density? Select the specimen, 295? Symbol of Disulphuret of Copper? Name as an independent mineral? Cu_2S . is found in combination in what?

Copper *pyrites*, which is a combination of Sulphuret of Cu. and Sulphuret of Iron.

192. TERSULPHURET OF ANTIMONY, SbS_3 , is the principal ore of that metal, and is known to mineralogists as *Antimony glance*.

Ill. 296. Specimen of SbS_3 .

BISULPHURET OF ARSENIC, AsS_2 , is found native of a red color and is called *realgar*. It is used as a pigment. The same may be said of the TERSULPHURET, AsS_3 , or *orpiment*.

Ill. 297. Specimens of AsS_2 and AsS_3 .

193. MONOSULPHURET OF MERCURY, HgS , is the chief ore of the metal, and is known as *cinnabar*. It is usually of a red color.

Ill. 298. Specimen of HgS .

Having noticed the most important Sulphurets, the next class of binary compounds demanding attention is, the class of Phosphurets, which, however, is not a very extensive nor important group.

The most interesting of these is—

194. PHOSPHURETTED HYDROGEN, consisting of P. and H. This gas is produced by the decomposition of water by means of P, assisted by some alkali, such as Lime or Potassa. It may also be formed by dropping Phosphuret of Calcium into water.

Phosphuretted Hydrogen has the singular property of taking fire spontaneously whenever let out into the air.

In O, if admitted no faster than it inflames, it may also be safely burned, producing at each inflammation a dazzling flash of light.

If it bubbles up through water into the open air, each bubble, as it inflames, forms a beautiful ring of smoke, made up of the Phosphoric acid resulting from the burning of the P.

192. Symbol, use, and mineralogical name of Sulphuret of Antimony? Select the specimen, 296? Symbols, source, common names and use of the two Sulphurets of Arsenic?

193. Symbol, use, common name, and color of Monosulphuret of Mercury? Select the specimen, 298? What class of binary compounds succeed the Sulphurets? Extent and importance?

194. Most interesting of the Phosphurets? Of what is Phosphuretted Hydrogen composed? Is produced in what two ways? Singular property? Burned in O.? Rings of smoke?

If the surrounding atmosphere is perfectly still, these rings, each consisting of thousands of others laterally joined, and rapidly whirling around, enlarge and rise unbroken to the ceiling.

The natural formation of this gas from the decay of substances containing P, and its spontaneous inflammation is thought to be the cause of the strange lights sometimes noticed at night, which have received the popular title of Will-wi'-a-wisp, and Jack-o'-the-lantern.

There are several Phosphurets of Hydrogen. The gas usually obtained is a mixture of different definite Phosphurets.

Ill. 299. Formation of Phosphuretted H, and its spontaneous inflammation with the rings of smoke.

Ill. 300. Bright flashes of light, by admitting Phosphuretted H. into O, over the pneumatic cistern.

The only binary compounds remaining to be noticed are—

THE ANHYDROUS OXACIDS.

195. An oxacid, or oxygen acid, is a substance consisting of O. and another simple, and having acid properties. It is said to be anhydrous when it is free from water, so as to have a strictly binary composition.

Sulphuric acid, SO_3 , *Nitric acid*, NO_3 , and *Silicic acid*, SiO_3 , may be mentioned as examples. The two former are seldom seen, and more rarely employed in their anhydrous state; nor are their acid properties, if possessed at all, very evident when in this condition. The latter being very abundant, both anhydrous and hydrous may be noticed more fully in this connection.

SILICIC ACID, SiO_3 . Density, 2.6.

196. This is the most abundant compound in nature, and exists extensively in a comparatively pure state, in which it is known by the terms *silica*, *quartz*, *rock crystal*, *flint*, etc.

Its presence in granite and most rocks and soils has been re-

Will-a-wisp? Composition of Phosphurets of Hydrogen? Describe *Ills.* 299 and 300! What class of binary compounds follow the Phosphurets?

195. Definition of *Oxacid*, or *Oxygen-acid*? When anhydrous? Name the examples of Oxacids, and give their symbols? Are SO_3 and NO_3 often seen anhydrous? Acid properties when anhydrous? What Oxacid is abundant in the anhydrous state? Symbol and density of Silicic acid?

196. Abundance of SiO_3 ? Natural state? Names? What substances contain SiO_3 ?

ferred to (Art. 71). It is insoluble in water, and comparatively inert, except at high temperatures, at which it strongly acts the part of an acid, decomposing carbonates, combining with bases, and forming salts called Silicates.

III. 301. Specimens of native SiO_2 .

III. 302. SiO_2 , fused with Carbonate of Soda, NaO, CO_2 , expels the Carbonic acid, CO_2 , and combines with the Soda.

197. Glass consists of Silicic acid, in combination with Potassa, Soda, Lime, Oxyd of Lead, or other bases, in variable proportions, according to the quality of glass.

There are, in all varieties of glass several equivalents of Silicic acid, to one of the base. If the base is in excess, the glass is soluble in hot water.

Porcelain is similar to glass, but contains a large share of Alumina, Al_2O_3 .

Since the Oxacids generally have a strong attraction for water, and for bases, and exist most commonly in a combination in which there are three elements, it will be proper to consider them under the head of—

TERNARY COMPOUNDS.

198. A *ternary* compound is one that consists of three simples. Most ternary compounds are commonly regarded as made up of two binary compounds, in both of which, however, there is a common simple, so that there are but three different elements.

THE HYDROUS OXACIDS, AND THE OXYELTS,

Are ternary substances containing O. They constitute the most extensive and important class of ternary substances.

199. As an example of a *Hydrous Oxacid*, we may take common, or Hydrous Sulphuric acid, $\text{H}_2\text{O}, \text{SO}_3$, which consists of the three simples, $\text{S}-\text{O}_2$, and H; but these are generally con-

Solubility? Action at high temperatures? Result of its combination with bases? Select some specimens of SiO_2 , 301? Describe the results of fusing SiO_2 with Carbonate of Soda, 302?

197. Composition of glass? Number of equivalents of acid and base in glass? In what case is the glass soluble? Porcelain? Why are the Oxacids mostly noticed under the head of *ternary compounds*?

198. Define a *ternary* compound? Common view in reference to the composition of ternary substances? What are hydrous Oxacids and Oxyelts? Extent and importance?

199. Name and symbol of the hydrous Oxacid mentioned as an example? Of how many simples, and how many equivalents of each does $\text{H}_2\text{O}, \text{SO}_3$, consist?

sidered to be combined, so as to form water, HO , a binary compound, and anhydrous Sulphuric acid, SO_3 , also a binary compound; and these two binaries are considered to be united with each other.

Here, then, O . is twice an element, being present both in the water and the anhydrous acid.

200. The Oxysalts, or Oxygen salts, are precisely similar to the Hydrous Oxacids in composition; the only difference being that the H . is replaced by a metal.

For example, Sulphate of Iron, FeO, SO_3 , like Hydrous Sulphuric acid, consists of three elements: Iron,— O ., and S ; the Iron, and an equivalent of O , being considered to be united to form Oxyd of Iron; the Sulphur combined with O_3 forming Sulphuric acid; and the acid and Oxyd united to constitute the Oxysalt, Sulphate of Iron.

A hydrous Oxacid, then, consists of an anhydrous Oxacid combined with water, or Oxyd of Hydrogen. An Oxysalt consists of an anhydrous Oxacid, combined with some base, which is an Oxyd of some metal.

201. It is to be noticed, however, that while some of the Oxacids are *Monobasic*, many of them are *bibasic*, *tribasic*, or even *quadribasic*, that is, are capable of combining with two, three, or four equivalents of base, as well as with one.

Also, with one or more equivalents of base, there may be, in some cases, several equivalents of acid; and as, in some of these compounds, there may be different bases, or different acids, there will arise *quaternary* compounds, or compounds of four elements, as well as those which are still more complex.

Common *alum*, which is Sulphate of Alumina and Potassa, $\text{Al}_2\text{O}_3, \text{KO}, 4\text{SO}_3$, is an Oxysalt of four ultimate elements.

The most important Oxacids and Salts may now be attended to. The Oxacids and Salts of the Cl . group are first in order, but none of these can receive attention but those which contain Cl .

How are these simples commonly regarded as being combined? How is O . twice an element?

200. What difference between Hydrous Oxacids, and Oxysalts? Similarity in composition of Sulphate of Iron to Hydrous Sulphuric acid, with the symbols of each? Of what does a Hydrous Oxacid consist? An Oxysalt?

201. What is meant in saying that some Oxacids are Monobasic, and others Bibasic, Tribasic, and Quadribasic? How many equivalents of acid may be combined with one of base? What are *quaternary* compounds? How may some Oxysalts be quaternary, or even more complex? Give the name, composition, and symbol of common *alum*, and tell why it is an example of a quaternary substance? What Oxacids and Salts are now in order, and which of them are sufficiently important to receive attention?

202. CHLORIC ACID, HO,ClO_3 , is a sour, sirupy liquid, which, by substitution of K. for H, becomes

CHLORATE OF POTASSA, KO,ClO_3 , a very important artificial salt seen in flat white crystals.

This is the substance chiefly used for obtaining O, of which it contains six equivalents. It readily yields O, as the following illustrations show :—

III. 303. A mixture of KO,ClO_3 ,—S, and charcoal detonates by friction, owing to the sudden burning of the S. and C, and the formation of Sulphurous acid, and Carbonic acid gases.

III. 304. KO,ClO_3 , and P, for a similar reason, detonate powerfully.

III. 305. S, alone, detonates with KO,ClO_3 .

III. 306. A mixture of KO,ClO_3 and sugar, burns rapidly on the application of a match.

203. KO,ClO_3 , may be decomposed by Sulphuric acid, so as to yield both Cl. and O; and if the temperature is kept low these two elements may be in combination to form other acid compounds of Cl, which will be decomposed by the slightest elevation in temperature, or the presence of any substance having an attraction for Cl.

III. 307. Sulphuric acid, and a few crystals of KO,ClO_3 , produce a gas which inflames Ether and explodes.

III. 308. These substances brought together under HO. in connection with P, produce inflammation of the P. under HO.

204. HYPOCHLORITE OF LIME. CaO,ClO , consisting of Lime CaO , and Hypochlorous acid, ClO , is the chief ingredient of common *bleaching powder*, incorrectly termed *chlorid of Lime*.

Bleaching powder is employed in disinfection as well as in bleaching. It is constantly, when of good quality, giving off ClO , which has an odor strongly resembling Cl. A little Sulphuric acid causes Cl. to be rapidly liberated from it.

III. 309. Specimen of bleaching powder.

202. Symbol and properties of Chloric acid? How does HO,ClO_3 become KO,ClO_3 , and what is the name of this salt? Importance, appearance, and use of KO,ClO_3 ? How many equivalents of O. does this salt contain? Explain the reason of the detonating properties of a mixture of KO,ClO_3 ,—S, and C, 303? What other detonating mixtures are used, 304, 305? What mixture, 306, burns rapidly?

203. Results of the action of Sulphuric acid on KO,ClO_3 ? Reaction, 307, between the gaseous product and ether? How is P. inflamed under water, 308?

204. Symbol and composition of Hypochlorite of Lime? Of what is CaO,ClO the chief ingredient? Uses and properties of bleaching powder? How is Cl. liberated from it? Select the specimen, 309?

The next Oxacids and salts requiring attention are those containing Sulphur.

[205. HYPOSULPHITE OF SODA, $\text{NaO}, \text{S}_2\text{O}_3$, is a crystalizable and very soluble artificial salt, employed in the Daguerreotype process, to dissolve the Iodid and Bromid of Silver from the plate after it comes from the mercury bath.

The anhydrous acid of this salt, known as Hyposulphurous acid, S_2O_3 , has not been isolated.

III. 310. Specimen of $\text{NaO}, \text{S}_2\text{O}_3$.

206. SULPHUROUS ACID, SO_2 , is produced by burning S. in air or in O. This substance is a gas, having a powerfully pungent odor, well known to all who are familiar with the burning of S.

It consists of S. and O, and is the only compound of these two elements that is formed by their direct combination. It may also be produced by the reaction between Cu. and HO, SO_3 .

It is very soluble in water, is liquefiable by cold, and is remarkable for its bleaching power, though colors are not permanently destroyed by it. Its salts, which are unimportant, are called *Sulphites*.

It has a strong attraction for O, with which it combines to form Sulphuric acid, SO_3 .]

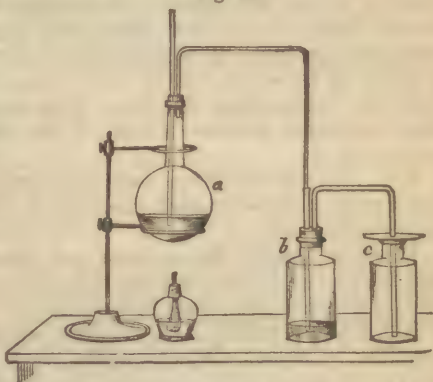
III. 311. SO_2 produced by burning S. in O.

III. 312. Its solution in water reddens and bleaches litmus.

III. 313. SO_2 obtained from SO_3 , by Cu, fig. 35.

III. 314. The reaction is between 2SO_3 and Cu, giving CuO, SO_3 and SO_2 . As the water, HO, of the

Fig. 35.



Sulphurous Acid from Sulphuric : the Gas washed and collected.

What Oxacids and Salts are next in order?

[205. Symbol, crystalizability, solubility, and use, of Hyposulphite of Soda? Isolation of the anhydrous acid? Select the specimen, 310?

206. Symbol, production, and properties, of Sulphurous acid? Composition of SO_2 ? Only product of the direct combination of S. and O.? By what reaction may SO_2 be produced? Solubility, liquefiability, and bleaching properties of SO_2 ? Name of its salts? How and why does SO_2 form SO_3 ? What is produced by burning S. in O., 311? Action of solution of SO_2 on litmus, 312? By what means is SO_2 obtained from SO_3 , 313? Reactions and products in obtaining SO_2 from SO_3 , 314?]

hydrous acid, undergoes no change, it need not be included in the explanation.

Ill. 315. SO_2 rapidly absorbed by water.

207. SULPHURIC ACID, HO,SO_3 , is the most important of all artificial chemical agents. When anhydrous, its formula is SO_3 , as before noticed.

It is abundant in nature, in combination, as in Sulphate of Lime (gypsum), $\text{CaO},\text{SO}_3,2\text{HO}$; and in the free state it sours some natural waters, as at Alabama, Genesee county, New York, and Rio Vinagre, South America.

Ill. 316. Specimen of $\text{CaO},\text{SO}_3,2\text{HO}$.

[Sulphuric acid is produced by two different processes: the original or German process, and the English. In the former, still practised at Nordhausen, it is obtained by heating moistened Sulphate of Iron, FeO,SO_3 , by which the Sulphuric acid, in a hydrous condition, having very nearly the composition $\text{HO},2\text{SO}_3$, is distilled.

The English process, more commonly practised, consists in burning S, and conveying the Sulphurous acid, SO_2 , which is formed, into a large room lined with lead, where it is so managed, that the SO_2 , by absorbing O, is converted into SO_3 , and is taken up by water, which, by boiling, is concentrated to have about the composition HO,SO_3 . This latter is called often the leaden-chamber process. Lead is but slightly affected by the acids of S.]

208. Common Sulphuric acid is a heavy,* colorless, oily-looking liquid,† intensely sour, destructive to organic tissues, and highly poisonous.

Wood is quickly decomposed and blackened by it, and the acid is often dark colored from the straw, cork, or other organic substances, that may have fallen into it.

HO,SO_3 gives off H, and oxydizes such metals as Iron, Zinc, and Tin, by means of the O. in the water combined with it, but the Oxyds are rapidly converted into Sulphates.

Ill. 317. Specimen of HO,SO_3 .

* Sp. gr. of HO,SO_3 , 1.84; water, 1.

† Called *oil of vitriol*.

What occurs when SO_2 is exposed to water, 315?

207. Symbol and importance of Sulphuric acid? Symbol when dry? Names and symbol of an abundant natural substance containing it? Sour natural waters? Designate the specimen, 316? [How many and what processes for the production of HO,SO_3 ? German process? English?]

208. Heaviness, color, and appearance, of HO,SO_3 ? Taste, and why poisonous? Why often dark colored? Reactions between HO,SO_3 and Fe., Zn, or Sn? Select the HO,SO_3 , 317?

Ill. 318. Wood blackened by HO, SO_3 .

Ill. 319. Tin acted upon by HO, SO_3 .

209. Common Sulphuric acid, HO, SO_3 , as well as the Nordhausen acid, $\text{HO}, 2\text{SO}_3$, and the anhydrous acid, SO_3 , has a strong attraction for water, and either of the latter two hiss like hot Iron when dropped into water.

Considerable heat is produced by the combination of these acids with water.

There is at least one other definitely Hydrous acid, $2\text{HO}, \text{SO}_3$, which crystalizes readily at 32° .

Ill. 320. Hissing sound by dropping $\text{HO}, 2\text{SO}_3$ into water.

Ill. 321. Ether boiled by the heat resulting from the combination of HO and HO, SO_3 .

210. Sulphuric acid is an exceedingly active agent, capable of decomposing many chemical compounds.

Its presence is detected by any solution containing Barium, in consequence of the formation of Sulphate of Baryta, an insoluble salt.

The use of Sulphuric acid in chemical operations and manufacturing processes, the preparation of Soda, dyeing, etc., is very extensive. By its means most other acids are obtained.

In combination, Sulphuric acid forms an extensive class of salts, called *Sulphates*.

Ill. 322. Alcohol lighted by means of a few crystalline grains of Chlorate of Potassa, and a drop of HO, SO_3 .

Ill. 323. A rapid combustion instituted by touching a drop of HO, SO_3 to a mixture of Chlorate of Potassa and sugar.

Ill. 324. Chlorid of Barium gives a white precipitate in a solution containing either free or combined HO, SO_3 .

211. SULPHATE OF SODA, NaO, SO_3 , *Eq.* $23 + 8, + 16 + 3 \times 8 = 71$. This is a substance well known and extensively used, as *Glauber's salt*. The crystals contain 10 equivalents of water, or 90 parts by weight, to one equivalent or 71 parts of the anhydrous salt.

The efflorescence of the crystals was referred to in Art. 164; also in Art. 164, that this salt is most soluble at 93° .

Action of the acid on wood, 318? Tin, 319?

209. Attraction of the different modifications of Sulphuric acid for water? Other hydrous Sulphuric acid, and properties? Action of $\text{HO}, 2\text{SO}_3$ on water, 320? Ether, how boiled, 321?

210. Sulphuric acid as a chemical agent? How detected, and why? Uses? Alcohol how inflamed, 322? Mixture of Chlorate of Potassa and sugar, 323? Action of Chlorid of Barium, 324?

211. Symbol, equivalent, and why, of Sulphate of Soda? Common name? Water of crystalization? Efflorescence? Solubility?

Great quantities of Sulphate of Soda are produced, and then converted into Carbonate of Soda, etc., in the process of manufacturing the Soda compounds from common salt.

Ill. 325. Specimen of crystals of $\text{NaO}, \text{SO}_3 + 10\text{HO}$.

SULPHATE OF BARYTA, BaO, SO_3 , has been referred to in Arts. 106 and 210.

SULPHATE OF STRONTIA, SrO, SO_3 . See Art. 109.

212. HYDROUS SULPHATE OF LIME, $\text{CaO}, 2\text{HO}, \text{SO}_3$, is a very abundant mineral, commonly known as *gypsum*.

Ground to powder, it is extensively employed in agriculture by the name of *plaster*.

When this powder is heated, its water is expelled; and, if the temperature has not been raised over 270° , the anhydrous gypsum will again absorb water, if made to a stiff paste, and become hard, or set.

Hence arises its use, as *plaster of Paris*, in stucco-work, stereotyping, and for making plaster casts of all kinds. If a solution of alum is mixed with the anhydrous gypsum, it becomes much harder.

The anhydrous Sulphate is also a natural substance.

Ill. 326. Hardening of moistened plaster of Paris; making casts, etc.

213. SULPHATE OF MAGNESIA, MgO, SO_3 , is well known as *Epsom salt*. Its medicinal use is considerable. Its employment as an antidote to poisoning by salts of Lead and Barium, was referred to in Arts. 106 and 124.

Ill. 327. Specimen of MgO, SO_3 .

214. SULPHATE OF ALUMINA AND POTASSA, $\text{KO}, \text{Al}_2\text{O}_3, 4\text{SO}_3$, is common *alum*.

The crystals of this salt contain 24 equivalents of water. By heating the crystals, this water is expelled, and the dry substance left is called *burned alum*. Alum is extensively employed in dyeing, and is used in medicine.

Extensive production? Select the specimen? Symbol of the Sulphate of Baryta? Of Strontia?

212. Symbol, abundance, and common name, of Hydrus Sulphate of Lime? Plaster? Preparation and use of plaster of Paris? Effect of moistening it with solution of alum? Anhydrous Sulphate of Lime? How are casts made, 326?

213. Symbol, common name, and use, of Sulphate of Magnesia? Select the specimen, 327?

214. Symbol and chemical name of *alum*? Water of crystalization? *Burned alum*? Uses of alum?

There are many other *alums* formed by the combination of Sulphate of Alumina with Sulphates of Potassa, Soda, etc.

Ill. 327, *a.* Specimen of $\text{KO}, \text{Al}_2\text{O}_3, 4\text{SO}_3 + 24\text{HO}$.

Ill. 327, *b.* Formation of burned alum.

215. MONOSULPHATE OF IRON, FeO, SO_3 .

This is commonly called *copperas* and *green vitriol*. It is a natural substance, but is manufactured extensively from native Sulphurets of Iron, and used in ink-making, dyeing, manufacturing Prussian blue, etc. The crystals contain 7HO .

Ill. 328. Specimen of $\text{FeO}, \text{SO}_3 + 7\text{HO}$.

Ill. 329. Formation of ink from infusion of galls and solution of FeO, SO_3 .

Ill. 330. Prussian blue formed from solution of FeO, SO_3 and Ferrocyanid of Potassium.

216. SULPHATE OF ZINC, ZnO, SO_3 , often called *white vitriol*, is produced in the process for obtaining H. from HO, by means of Zn, as noticed Art. 77.

It is a strong emetic, and is employed in medicine and surgery. The crystals contain 7HO .

Ill. 331. Specimen, $\text{ZnO}, \text{SO}_3 + 7\text{HO}$.

217. SULPHATE OF COPPER, CuO, SO_3 , called *blue vitriol*, is a native substance.

It is used in dyeing and in medicine. Like all other salts of Copper it is poisonous.

Ill. 332. Specimen $\text{CuO}, \text{SO}_3 + 5\text{HO}$, the crystals containing five equivalents of water.

Ill. 333. The following table contains the Sulphates now noticed:—

Sulphate of Soda,	NaO, SO_3 ,	Glauber's salt.
Sulphate of Magnesia,	MgO, SO_3 ,	Epsom salt.
Sulphate of Lime,	CaO, SO_3 ,	plaster of Paris.
S. of Alumina and Potassa,	$\text{KO}, \text{Al}_2\text{O}_3, 4\text{SO}_3$,	common alum.
Sulphate of Iron,	FeO, SO_3 ,	green vitriol.
Sulphate of Zinc,	ZnO, SO_3 ,	white vitriol.
Sulphate of Copper,	CuO, SO_3 ,	blue vitriol.
Sulphate of Hydrogen,	HO, SO_3 ,	oil of vitriol.

Other alums? Select the specimen, 327, *a.*?

215. Chemical name, symbol, sources, and uses, of copperas? Water of crystallization? Select the specimen, 328? Ink, how formed, 329? Prussian blue, 330?

216. Symbol, common name, production, and use of Sulphate of Zinc? Water of crystallization? Select the specimen, 331?

217. Symbol, common name, source, uses and properties of Sulphate of Copper? Select the specimen, 332? Give the chemical and common names, and the symbols of the Sulphates, 333?

Next in order are—

THE OXACIDS AND SALTS CONTAINING NITROGEN.

218. It was noticed, Art. 159, that Binoxyd of Nitrogen, by absorbing O, produces reddish vapors of *Nitrous acid*, NO_3 , or *Hyponitric acid*, NO_4 .

One or the other of these substances is formed, according to the quantity of O. admitted to the Binoxyd.

They do not require further description.

NITRIC ACID, NO_5 ; HYDROUS, HO, NO_5 , is the most important compound of N. and O.

It is found in very minute quantity in rain water, especially in thunder showers; and is considered to be produced by the electric discharges, which cause some of the N. and O. of the air to combine and form it.

It also exists as an element of native Nitrate of Potassa, KO, NO_5 (saltpetre), and in Nitrate of Soda abundant near the northern frontier of Chili, and in other Nitrates.

HO, NO_5 is most easily obtained from Nitrate of Soda, NaO, NO_5 , by the action of Sulphuric acid, in which case Sulphate of Soda, NaO, SO_3 , is formed.

Nitric acid of the formula HO, NO_5 , has a density of about 1.52; but the commercial acid, having more water, is specifically lighter.

It is a colorless liquid, though often colored by the presence of NO_4 ; and then commonly called "Aqua fortis."

219. It is one of the most energetic Oxydizing agents known, since it contains five equivalents of O, and readily yields three of them to substances capable of oxydation.

It corrodes or Oxydizes all the common metals except Gold and Platinum. It Oxydizes and bleaches Indigo, rapidly destroys organic tissues, turns the cuticle yellow and kills it, and is highly poisonous.

Nitric acid is used in galvanic batteries; in medicine and surgery; in dyeing, staining wood, dissolving metals, etc.

What Oxacids and Salts are next in order?

218. Production and symbols of Nitrous and Hyponitric acids? Symbol of anhydrous, and of hydrous Nitric acid? Importance? Sources? HO, NO_5 , how obtained; chemical changes and product? Density of HO, NO_5 ? Of the commercial acid and why? Color and taste? *Aqua fortis*?

219. Oxydizing power, and why? Action on metals, indigo, tissues, and the skin? Poisonous? Uses?

It forms a class of soluble salts called Nitrates. It is slowly decomposed into O. and NO_2 , and hence becomes colored by the action of light.

Ill. 334. Specimen of commercial Nitric acid.

Ill. 335. HO, NO_5 distilled from NaO, NO_5 , by heat and HO, SO_3 .

Ill. 336. Action of HO, NO_5 on cork, which is rapidly eaten away.

Ill. 337. Indigo blue destroyed by HO, NO_5 .

Ill. 338. Copper converted into a soluble Nitrate, and red fumes formed by the action of HO, NO_5 .

Ill. 339. Gold dissolved in *aqua regia*, a mixture of HO, NO_5 and solution of HCl , Art. 141.

220. NITRATE OF POTASSA, KO, NO_5 .

This salt is known as *nitre* and *saltpetre*.

It is chiefly used in making gunpowder and fireworks, since it contains a large quantity of O, which it yields to the combustibles with which, in these preparations, it is mixed, and thus enables them to burn independently of the atmosphere, and in confined places.

Ill. 340. Specimen KO, NO_5 .

Ill. 341. Rapid combustion of Sugar mixed with KO, NO_5 .

Ill. 342. Deflagration of KO, NO_5 on ignited charcoal.

NITRATE OF SODA, NaO, NO_5 , is a mineral, valuable for the Nitric acid which it contains, and useful in the culture of the soil, Art. 218.

Ill. 343. Specimen NaO, NO_5 .

221. NITRATE OF SILVER, AgO, NO_5 , is made by dissolving Ag. in HO, NO_5 .

It forms transparent, anhydrous crystals; and, fused into moulds, the sticks are called *lunar caustic*, and used in surgery. It is valuable as a test for Cl.

Since it decomposes and blackens by contact with organic matter, its solution, thickened with gum, constitutes an indelible ink, much used for marking linen and cotton.

Its stain is removed by solution of Cyanid of Potassium. Nitrate of Silver is also an element of most hair dyes.

Names and properties of its salts? Action of light? Select the specimen, 334? How prepared, 335? Action on cork, 336? Indigo, 337? Cu, 338? Aqua regia and Au, 339?

220. Symbol, and common names of Nitrate of Potassa? Uses and why? Select the specimen, 340? Sugar rapidly burned, 341? Deflagration, 342? Symbol and value of Nitrate of Soda? Specimen, 343?

221. Symbol, and production of Nitrate of Silver? Appearance? Lunar caustic? Uses? Indelible ink, and why? Stain how removed?

Ill. 344. Specimen AgO, NO_5 .

Ill. 345. Precipitation of the Cl. from Chlorids by means of AgO, NO_5 .

The next class of substances, comprises

THE OXACIDS AND SALTS OF PHOSPHORUS.

222. *Hypophosphorus acid*, PO , and *Phosphorus acid*, PO_3 , may be studied in larger works.

PHOSPHORIC ACID, PO_5 , is remarkable for the Hydrates which it forms, as well as for its monobasic, bibasic, and tribasic salts.

The anhydrous acid, PO_5 , may be formed as a white solid, by burning P. in dry O. It has a strong attraction for water, and forms by combining with it, three Hydrates, HO, PO_5 , $2\text{HO}, \text{PO}_5$, and $3\text{HO}, \text{PO}_5$. Phosphoric acid may be formed by the action of Nitric acid on P, but great care is requisite in the process, as a violent explosion may occur.

223. The different modifications of Phosphoric acid are, then, the following:—

Anhydrous	Phosphoric acid,	PO_5 .
Monobasic	“	“ HO, PO_5 .
Bibasic	“	“ $2\text{HO}, \text{PO}_5$.
Tribasic	“	“ $3\text{HO}, \text{PO}_5$.*

[224. The modifications of Phosphoric acid give rise to a variety of Phosphates, with the same base; since in a bibasic salt, for example, there may, or there may not be, an equivalent of basic water. The following Phosphates of Soda are illustrations.]

Monobasic Phosphate of Soda,	NaO, PO_5 .	Salt No. 1.
Bibasic Phosphates of Soda	$\text{HO}, \text{NaO}, \text{PO}_5$.	“ 2.
	$\text{NaO}, \text{NaO}, \text{PO}_5$.	“ 3.
Tribasic Phosphates of Soda	$\text{HO}, \text{HO}, \text{NaO}, \text{PO}_5$.	“ 4.
	$\text{HO}, \text{NaO}, \text{NaO}, \text{PO}_5$.	“ 5.
	$\text{NaO}, \text{NaO}, \text{NaO}, \text{PO}_5$.	“ 6.

* It is to be understood that a large figure placed *before* letters multiplies all the letters as far as the first comma, while a small figure placed after a letter multiplies merely that letter. Thus, $3\text{HO}, \text{PO}_5 = \text{H}_3, \text{O}_3, \text{P}, \text{O}_5$.

Specimen, 344? Cl. how precipitated, 345?

222. What is said of PO . and PO_3 ? Symbol of Phosphoric acid? For what is PO_5 remarkable? How formed anhydrous? Attraction for HO , and results of its combination? How formed by NO_5 ?

223. Names and symbols of the different modifications of Phosphoric acid?

224. [How arise several Phosphates of the same base? Symbol of the Monobasic Phosphate of Soda? The Bibasic Phosphates? Tribasic?]

[Of these six Phosphates of Soda three contain basic water, which is independent of the water of crystalization, and which, unlike this latter, is not expelled at a moderately elevated temperature.]

The tribasic Phosphates are distinguished from the others, by giving, with Nitrate of Silver, AgO, NO_3 , yellow precipitates of tribasic Phosphate of Silver, while with the others, the precipitates are white.

$\text{HO}, 2\text{NaO}, \text{PO}_5$, which is salt No. 5, is the common medicinal Phosphate of Soda of the shops.]

Ill. 347. Phosphoric acid formed by burning P. in O.

Ill. 348. Formation of Phosphoric acid by the action of HO, NO_5 on P.

Ill. 349. Specimen of $\text{HO}, 2\text{NaO}, \text{PO}_5$.

Ill. 350. Reaction between solutions of $\text{HO}, 2\text{NaO}, \text{PO}_5$, and AgO, NO_3 .

225. PHOSPHATES OF LIME. These are as numerous as the Phosphates of Soda; but the most important is that which constitutes the chief mineral element of bones; and is thought to be a combination of two tribasic phosphates, having the formula, $2(3\text{CaO}, \text{PO}_5) + 2\text{CaO}, \text{HO}, \text{PO}_5 = 8\text{CaO}, \text{HO}, 3\text{PO}_5$.

The mineral known as *apatite*, is of variable composition, yet consists always of an anhydrous tribasic phosphate, combined with a haloid salt; but it generally contains a large share of Phosphate of Lime. A Phosphate of Lime having a large ratio of Phosphoric acid, and hence called Superphosphate, is considerably manufactured for agricultural use, in order to supply an exhausted soil with P.

Ill. 351. Specimen of *apatite*.

ANHYDROUS CARBONIC ACID, CO_2 . $6 + 2 \times 8 = 22$. *D.* 1.5; *Air*, 1.

226. This substance, the most important compound of Carbon and Oxygen, is a gas, but is liquefiable by pressure and cold, and even solidifiable. It is also readily soluble in water. It is colorless, tastes sour, and is $1\frac{1}{2}$ times as heavy as air.

CO_2 may be produced anhydrous, by burning charcoal in O; both being dry.

There seems to be reason to consider the composition of anhydrous Carbonic acid as C_2O_4 , and the hydrous acid as $2\text{HO}, \text{C}_2\text{O}_4 = \text{H}_2\text{C}_2\text{O}_5$.

Carbonic acid is one of the more abundant natural substances.

[How many of these Phosphates contain basic water? Distinction between basic water, and water of crystalization? The Tribasic Phosphates, how recognised? Medicinal Phosphate?]

Phosphoric acid how formed, 347? 348? Specimen, 349? Reactions, 350?

[225. Phosphates of Lime? Most important and symbol? *Apatite*? Artificial phosphates and use?] Specimen, 351? Symb. equiv. and density of anhydrous Carbonic acid?

226. Importance? Form, liquefiability, and solidifiability? Color, taste, and heaviness? How produced? [Proper formula of the anhydrous and the hydrous acid?] Abundance of CO_2 ?

It forms something less than $\frac{1}{1000}$ part of the atmosphere, and is generally present in natural waters.

Fig. 36.



Charcoal burning in
Oxygen.

It is thrown out by volcanoes and springs, and is produced, as previously noticed (Art's. 31 and 66), by the breathing of animals, the burning of fires, fermentation, and the decay of organic matter; and it exists extensively as a Carbonate in the various modifications of Limestone, in coral, shells, and bones.

Ill. 352. Carbonic acid produced by burning C. in O, fig. 36.

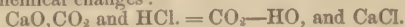
227. From the Carbonates, Carbonic acid is expelled by nearly all other acids. It is itself a very stable substance, being incapable of supporting the combustion of any substance except Potassium (*Ill. 149*).

Carbonic acid, is, however, decomposed with the aid of light, by verdant plants; its C. going to form a part of the vegetable tissues, while most of its O. is liberated; it is therefore the chief support of the vegetable kingdom.

Ill. 353. CO_2 separated from marble, *i. e.*, Carbonate of Lime, CaO, CO_2 , by the action of Chlorohydric acid, HCl , with the formation of Water, HO , and of Chlorid of Calcium, CaCl .

For this process and the collection of the gas over water, a bottle may be arranged as in fig. 37, page 109.

Ill. 354. Chemical changes:



Ill. 355. CO_2 collected, in the usual way, over water.

Ill. 356. CO_2 obtained from marble and collected by displacing air, fig. 38. For this purpose some pieces of marble being placed in the bottle, *a*, are covered with water. HCl is introduced through the straight tube, as wanted, and the gas passing through the bent tube collects in *b*.

Ill. 357. Free solubility of CO_2 in water, and formation of a vacuum as before seen in fig. 34, *Ill. 287*.

Ill. 358. CO_2 obtained mingled with a cloud of Carbonate of Ammonia, by pouring Nitric acid on solid Carbonate of Ammonia; Nitrate of Ammonia is formed.

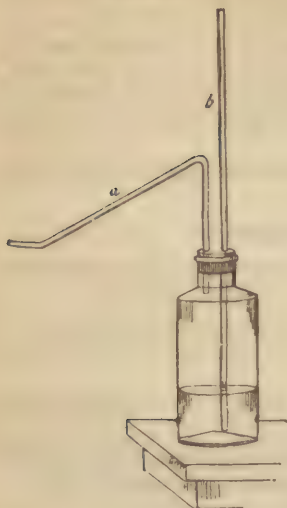
Ill. 359. On account of its superior density, Carbonic acid is poured like water from one vessel to another, or downward through the air.

Ill. 360. A taper instantly extinguished in Carbonic acid.

Sources, and natural conditions of CO_2 ? Result of burning C. in O, 352?

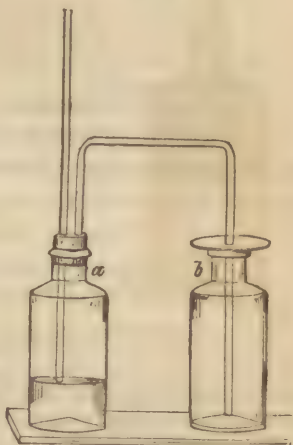
227. How is CO_2 expelled from Carbonates? Stability? Action of verdant plants? Chief support of the vegetable kingdom? CO_2 how separated from the marble and what are the products, 353? Draw a diagram on the blackboard representing the chemical changes and explain them, 354? CO_2 how collected, 355? Apparatus, &c., for obtaining CO_2 and collecting over air, 356? Explain the solution of CO_2 , as in 357? Process for obtaining CO_2 from Carbonate of Ammonia, 358? Why poured, 359? Taper, 360?

Fig. 37.



Arrangement to evolve Carbonic acid for collection over water.

Fig. 38.



Evolution and collection of Carbonic acid by displacement of Air.

228. Carbonic acid in the lungs is perhaps the most deadly of all poisons; when pure, producing death in a few seconds, and when constituting 8 or 10 per cent. of the air, acting like a narcotic poison, rapidly causing stupor, weakness, and death.

Thousands of lives have been destroyed by this gas, arising from its various sources; such as respiration in close apartments; from fires, and flames of all kinds where it is not freely carried off; from lime-kilns; and from its natural sources, sinking into caves, mines, wells, and cellars, where it is known vulgarly as *choke damp*.

It is to be remembered that where a candle will not burn an animal can not live; and therefore suspected places may always in this way be tested.

III. 361. Rats or mice killed in less than a minute by throwing Carbonic acid into a bell glass or jar in which they are confined.

229. In the stomach in moderate quantity, Carbonic acid is healthful, and its solution is a common drink, when sweetened, under the name of *Soda water*, or *mineral water*. By the pres-

228. CO₂ in the lungs? Destruction of life and various causes? Choke damp? Testing suspected places? Animals killed, 361?

229. CO in the stomach?

sure of a force pump, a strong iron vessel nearly filled with water is highly charged with Carbonic acid, evolved, by the action of Sulphuric acid, from refuse powder and small pieces of marble.

Real Soda water, to which, however, the other is preferable, may be produced by dissolving separately, equivalent parts of pulverized Tartaric acid, and Bicarbonate of Soda, and pouring the solutions together.

This gas is also the cause of the effervescence of wines, beer, and the simpler effervescing drinks.

Ill. 362. Formation of Soda Water from the powders.

230. A test for Carbonic acid is lime water, by means of which it is precipitated as Carbonate of Lime, CaO, CO_2 .

Ill. 363. Clear solution of Carbonic acid rendered turbid by lime water.

Ill. 364. When the breath is forced through lime water, CaO, CO_2 is precipitated.

Ill. 365. When lime water is thrown into a jar in which a taper has been burning, the clear water becomes chalky from the formation of CaO, CO_2 .

Ill. 366. When the air in a bell glass is breathed over, it instantly extinguishes a candle, on account of the Carbonic acid exhaled from the lungs.

Ill. 367. The solution of Carbonic acid, like other acids, reddens litmus.

231. CARBONATE OF POTASSA, KO, CO_2 , is one of the chief substances in *potash*, and it forms the larger part of *pearlash*, although these commercial articles are quite variable in composition.

When solution of pearlash is aerated by a stream of Carbonic acid gas, and the water of solution separated, it constitutes what is commonly called *salaeratus*, and contains Bicarbonate of Potassa, $\text{KO}, 2\text{CO}_2$.

Salaeratus and pearlash are used to make cake light, by means of the liberation from them of Carbonic acid gas, which, getting involved in the dough, causes it to be spongy.

The Carbonic acid is liberated in the dough partly by the heat in baking, and partly by the use of sour milk, or of some article containing acid. Salaeratus should not be dissolved in hot water, since it then loses some of its Carbonic acid.

The purest commercial form of Carbonate of Potassa is known as *salt of tartar*, since it is prepared from *cream of tartar*, a Tartrate of Potassa.

Soda water how manufactured? Real Soda water? Which preferable?

230. Test for CO_2 ? Action of CO_2 on solution of CaO , 363? Breath forced through Lime water, 364? Lime water and burning, 365? Breathed air and candle, 366? Litmus, 367?

231. Symb. of Carbonate of Potassa? Potash, pearlash, and salaeratus? Uses? Hot water? Salt of tartar?

Ill. 368. Specimens of *potash*, *pearlash*, *salaeratus*, and *salt of tartar*.

Ill. 369. Effervescence of Carbonate of Potassa with acids.

232. CARBONATE OF SODA, NaO, CO_2 forms a large share of *Soda ash*, a commercial article produced in the furnace from Sulphate of Soda, in the *Soda process*.

It is comparatively pure in the article sold as *washing soda*, and as Carbonate of Soda. The crystals generally contain 10 equivalents of water.

This article facilitates washing by uniting with greasy matters to form soap; by precipitating the Lime in hard water, as a Carbonate, and by preventing the decomposition of soap and the formation of insoluble lime soap.

As it has a strong alkaline reaction, if used too freely in the laundry, it destroys the texture of the articles washed.

Ill. 370. Specimen of commercial Carbonate of Soda.

Ill. 371. Alkaline reaction of NaO, CO_2 ; turmeric turned brown, and cabbage water green.

233. BICARBONATE OF SODA, $\text{NaO}, \text{HO}, 2\text{CO}_2$ is known commonly as *baking soda*, being very considerably used in the same way as *pearlash* and *salaeratus* in bread and cake making. It is greatly preferable to either of those articles.

The too liberal use of these alkaline Carbonates in food is undoubtedly injurious to health, especially if not properly neutralized by the acids of sour milk, cream of tartar, or (as referred to in Art. 141) by Chlorohydric acid.

The last substance, with proper care, is the best and cheapest to be used in connection with $\text{NaO}, \text{HO}, 2\text{CO}_2$, since common salt is the only fixed product.

$\text{NaO}, \text{HO}, 2\text{CO}_2$ (sometimes called supercarbonate) is also employed in connection with Tartaric acid, and other substances, to prepare Soda water and other effervescing drinks.

Ill. 372. Specimen of $\text{NaO}, \text{HO}, 2\text{CO}_2$.

Ill. 373. Effervescence of $\text{NaO}, \text{HO}, 2\text{CO}_2$ with HCl ; Chlorid of Sodium, NaCl . and water formed, and Carbonic acid, CO_2 evolved as seen in

Specimens, 368? Action of acids on KO, CO_2 , 369?

232. Symb. of Carbonate of Soda, and why? * Soda ash? Washing Soda? Water of crystalization? Why used in washing? Free use? Specimen, 370? Action of NaO, CO_2 on turmeric, &c., 371?

233. Symb. of Bicarbonate of Soda, and why? Baking Soda? Too liberal use in food? Best substance with which to neutralize $\text{NaO}, \text{HO}, 2\text{CO}_2$, and why? Effervescing drinks? Specimen, 372? $\text{NaO}, \text{HO}, 2\text{CO}_2$, how made to effervesce, and what are the products, 373?

* Let the learner tell what NaO , stands for; also, CO_2 and $\text{Na}, \text{—O}, \text{—C}$, and O_2 , severally.

Ill. 374. $\text{NaO}, \text{HO}, 2\text{CO}_2$ and $\text{H.Cl} = \text{NaCl}, -2\text{HO}$, and 2CO_2 .

Carbonate of Baryta, was referred to in Art. 106, and Ill. 166.

Carbonate of Strontia, in Art. 109.

234. CARBONATE OF LIME, CaO, CO_2 , constitutes marbles, chalk, and other varieties of limestone.

It is pure and crystalized in some specimens of calcspar, or Iceland spar, and is abundant in shells, corals, and bones. By heating it in kilns, the Carbonic acid is expelled, and Lime is obtained.

CaO, CO_2 is slightly soluble in pure water, and more readily in water containing Carbonic acid, as natural water generally does.

On this account, it is often present with other substances, in spring and well water; but is partly deposited from them in boiling, which expels the Carbonic acid. Besides CaO, CO_2 is less soluble in hot, than in cold water. It is also left by the evaporation of the water. Hence vessels in which water is boiled, become coated with impure Carbonate of Lime.

235. In limestone districts, as in Schoharie county, New York, extensive caves have been excavated by the combined frictional and solvent action of water. From the roof of these numerous icicle-like pendants, of Carbonate of Lime, often translucent, and called *stalactites*, hang suspended, and similar formations, or *stalagmites*, rise from the floor.

The incrustations take every variety of fantastic shape, and are sometimes very beautiful. They are formed by the solution of the rock, in water which subsequently evaporates. In these caves, Carbonate of Lime in every form and condition is seen.

One of the most remarkable, said to have been explored some twenty miles, so easy of access that ladies often penetrate it three or four miles, and constantly visited, is known as Howe's cave. It is near East Cobleskill, some thirty miles west of Albany, New York.

Ill. 375. Specimens of various forms of natural Carbonate of Lime.

Ill. 376. Effervescence of marbles and coral, in acid.

Ill. 377. Limestone, when heated to a bright red heat, by a blowpipe or otherwise, becomes caustic and reacts alkaline, being converted into Lime.

236. CARBONATE OF MAGNESIA, MgO, CO_2 , is the common magnesia of the shops. It is found native, and is also manufactured.

Chemical changes on the blackboard, 374? Carbonates of Baryta and Strontia?

234. Symb. of Carbonate of Lime, and why? Natural states? Lime, how obtained? Solubility of CaO, CO_2 ? Coating of vessels in which water is boiled?

[235. Limestone caves, their origin and curiosities? Example?] Specimens, 375? Action of acids, 376? Of heat, 377?

236. Symb. of Carbonate of Magnesia, and why? Sources?

Ill. 378. Specimen of MgO,CO_2 .

CARBONATE OF IRON, FeO,CO_2 , is an abundant and valuable ore of the metal, known mineralogically as *spathic Iron* and *sparry Iron*.

Ill. 379. Specimen of FeO,CO_2 .

There are *Carbonates of Zinc and Copper*, which are valuable ores of those metals.

*Ill. 380. Specimen of calamine, or native Carbonate of Zinc, ZnO,CO_2 .**Ill. 381. Specimens of native Carbonates of Copper.*

CARBONATE OF LEAD, PbO,CO_2 , is a substance extensively manufactured and used as a white paint, by the name of *white lead*.

Ill. 382. Specimen of PbO,CO_2 .

Other Carbonates will be found described in the larger treatises.

237. *Silicic Acid, and the Silicates*, were noticed as far as space will permit, in Arts. 71, 73, 195, 196, 197.

The sources and use of *Boracic Acid*, BO_3 , were referred to in Art. 74. This acid is remarkable for imparting a green tint to the flame of alcohol.

Ill. 383. Burning alcohol in which there is Boracic acid.

The most important salt of Boracic acid is the

BIBORATE OF SODA, $NaO,2BO_3$, known as *borax*, and used in tinning, welding, &c., and in mineralogy as a blowpipe reagent. Its crystals contain 10 equivalents of water.

Ill. 384. Specimen of $NaO,2BO_3+10HO$.

There are many acids consisting of O. and a metal, as well as salts which these acids form, but which can not be noticed in this course. The most important will receive attention.

238. CHROMIC ACID, CrO_3 , may be obtained by mixing a measure of cold saturated solution of Bichromate of Potassa, $KO,2CrO_3$, with one and a half measures of Sulphuric acid,

Specimen, 378? Symb. of Carbonate of Iron, and why? Uses and mineralogical names? Specimen, 379? Carbonates of Zn. and Cu? Specimens, 380, 381? Symbol, source, use, and common name of Carbonate of Lead? Specimen, 382? Other Carbonates?

237. Silicic acid and the Silicates? Symb. of Boracic acid, and why? Remarkable property? Most important salt, symb., and why? Uses of $NaO,2BO_3$? Water of crystalization? Specimen, 384? Acids and salts not noticed?

238. Symb. of Chromic acid, and why? How obtained?

HO, SO_3 . The mixture becomes hot when made, and, as it cools, the CrO_3 crystalizes in fine slender blood-red prisms. These may be dried on a brick covered from dust, &c.

CrO_3 is a powerful oxydizing agent, and is rapidly decomposed and converted into Oxyd of Chromium by contact with organic matter.

Ill. 385. Preparation of CrO_3 .

Ill. 386. Ether inflamed, by dropping into it some crystals of CrO_3 .

239. CHROMATE OF POTASSA, KO, CrO_3 , is a beautiful yellow salt, extensively manufactured from Chrome Iron. It is the source of the Chromium compounds.

Ill. 387. Specimen of KO, CrO_3 .

BICHROMATE OF POTASSA, $\text{KO}, 2\text{CrO}_3$, is manufactured from KO, CrO_3 . Its crystals are of a splendid red color.

Ill. 388. Specimen of $\text{KO}, 2\text{CrO}_3$.

240. CHROMATE OF LEAD, PbO, CrO_3 , is a beautiful yellow pigment, made as below:—

Ill. 389. Precipitation of PbO, CrO_3 from the reaction between Acetate of Lead and Bichromate of Potassa. Acetate of Potassa remains in solution.

Ill. 390. Precipitation of reddish Chromate of Silver, from the Nitrate, by KO, CrO_3 .

Ill. 391. Precipitation of yellow Chromate of Baryta, from Chlorid of Barium, BaCl , by means of Chromate of Potassa, KO, CrO_3 .

Ill. 392. Precipitation of deep yellow Chromate of Zinc from the Chlorid, ZnCl , by means of Chromate of Potassa, KO, CrO_3 .

Ill. 393. Brick-red Chromate of Mercury formed from Chlorid of Mercury, HgCl , and Chromate of Potassa, KO, CrO_3 .

241. CHLOROCHROMIC ACID, CrO_2Cl , may be distilled from a mixture of 3 parts of Bichromate of Potassa, $3\frac{1}{2}$ of Chlorid of Sodium, and 9 of Sulphuric acid.

This acid is remarkable for its close resemblance to Bromine in color, odor, density, and volatility. Its color is, however, a

Crystalline appearance? How dried? Oxydizing agent? Action on organic matter? Ether, how inflamed, 386?

239. Symbol, appearance, source, and use, of Chromate of Potassa? Specimen, 387? Symbol, source, and appearance, of Bichromate of Potassa? Specimen, 389?

240. Symbol and description of Chromate of Lead? Preparation and changes, 389? Precipitation and appearance of Chromate of Silver, 390? Chromate of Baryta, 391? Chromate of Zinc, 392? Chromate of Mercury, 393?

241. Symbol of Chlorochromic acid, and why? How distilled? Remarkable properties?

finer red. By water it is decomposed into Chromic and Chlorohydric acids.

III. 394. Formation and distillation of CrO_2Cl .

III. 395. Decomposition of CrO_2Cl by water.

242. ARSENIOUS ACID, AsO_3 , is commonly called *arsenic*, though that term is properly applied only to the simple metal. It is also known as *white arsenic*, and *ratsbane*.

AsO_3 is perhaps the most active of the mineral poisons. It is used for the destruction of rats, flies, etc., and is employed to some extent in medicine.

The only proper antidote to its poisonous effects is recently prepared hydrated Sesquioxide of Iron.*

The presence of Arsenious acid may be detected by Sulphydric acid, Ammonia-Nitrate of Silver, or Ammonia-Sulphate of Copper. In cases of suspected poisoning, these and other methods are employed, and greater certainty is obtained by bringing the Arsenic to the metallic state.

III. 396. Specimen of AsO_3 .

III. 397. Precipitation of yellow AsS_3 from solution of AsO_3 by HS.

III. 398. Precipitation of green Arsenite of Copper from solution of AsO_3 , by means of Ammonia-Sulphate of Copper.

III. 399. Yellow Arsenite of Silver precipitated from solution of AsO_3 , by means of Ammonia-Nitrate of Silver.

It has not been thought necessary to go further with the Oxacids and Oxysalts. Next follow—

SULPHUR SALTS.

244. These do not here require more than a general notice. In their composition, they are precisely similar to the Oxysalts, but they contain S. instead of O, and consist of a Sulphur acid united to a Sulphur base.

Thus Sulphydrate of Potassa, KS,HS , corresponds to ordinary Hydrate of Potassa, or Oxhydrate, KO,HO , which may itself be regarded as a salt

* See *Acidum Arseniosum* in the U. S. Dispensatory.

Action of water? III. 394? 395?

242. Symbol of Arsenious acid, and why? Common names? Poison? Uses? Antidote?

243. AsO_3 how detected? Certainty in cases of poisoning? Specimen, 396? Precipitation by Sulphuretted Hydrogen, 397? By Ammonia-Sulphate of Copper, 398? By Ammonia-Nitrate of Silver, 399? What class of salts follow the Oxysalts?

244. Notice of the Sulphur salts required? Their composition?

[Examples? Composition and symbol of the Sulphydrate of Potassa?

of Potassa, the water, HO, acting the part of an acid. Also Sulpharsenate of Potassa, KS,AsS_5 , corresponds to Arsenate of Potassa, KO,AsO_5 ; and Sulphocarbonate of Potassa, KS,CS_3 , to Carbonate of Potassa, $\text{K}_2\text{O,CO}_2$.

Here Sulphuret of Potassium, KS, is a Sulphur base, like Oxyd of Potassium, KO, with which Sulphydric acid, HS, Sulpharsenic acid (Pentasulphuret of Arsenic), AsS_5 , and Sulphocarbonic acid (Bisulphuret of Carbon), CS_3 , combine like the Oxacids to produce Sulphur salts, like the Oxygen salts or Oxy salts.

245. There are several other classes of salts, interesting to the scientific Chemist, but not requiring special mention in the present course.

The substances demanding attention, which are properly the subjects of Organic Chemistry, and which have not already been noticed, will be referred to in the third part of this work.

ORGANIC AND INORGANIC CHEMISTRY.

246. That portion of the science of Chemistry which relates to animal and vegetable bodies, and their natural and artificial products, is termed *Organic Chemistry*.

Inorganic Chemistry is, therefore, the Chemistry of *mineral substances*, and their artificial derivatives, as distinguished from animal and vegetable products, and their derivatives.

There are many substances, as will hereafter be seen, intimately related to both Organic and Inorganic Chemistry, but none, perhaps, that so remarkably form the connecting links of these two divisions as Ammonia and its compounds; and these, therefore, so far as they can now be understood, will next receive attention.

AMMONIA, NH_3 . Eq. $14+3\times 1=17$. D. 0.597; Air, 1.

247. The name of this substance is of very ancient and rather uncertain origin. It is, besides, an exception to the rule, that a single word should indicate a simple substance; for, as is implied by its symbol, Ammonia is composed of Nitrogen and Hydrogen.

As in case of Lime, a long established name has been adopted as a scientific term, but in this case with the additional reason that Ammonia belongs quite as much as otherwise to Organic Chemistry, in which the rule referred to is totally disregarded.

[To what is it similar? Sulpharsenate of Potassa? Sulphocarbonate? The base in all these salts? The acids?]

245. Interest of other classes of salts?

[What substances are noticed in Organic Chemistry?]

246. Definition of Organic Chemistry? Inorganic? What class of substances is intimately related to both? Symbol of Ammonia, and why? Equivalent, and why? Density?

[247. Origin of its name? Exception to what rule? Reasons?]

248. The sources of Ammonia are extensive. It is found in rain-water, and is a constant element of the atmosphere, though forming a minute and somewhat variable portion of that body.

It passes into the atmosphere from a variety of causes. It is exhaled at times by animals and certain plants, and set free by the natural decomposition of animal and vegetable substances. It is also a result of the action of Electricity upon the atmosphere, as well as a volcanic product.

249. It may be produced by the action of Electricity upon a mixture of its elements; by their direct combination, when one or both is in the *nascent* condition (Article 136); and by a variety of chemical reactions.

The usual process to obtain NH_3 is by the action of Lime, CaO , upon Chlorid of Ammonium, NH_4Cl , in which case Chlorid of Calcium, CaCl , and water, HO , are also formed; since CaO and NH_4Cl contain the same equivalents as NH_3 — CaCl , and HO .

250. NH_3 is a colorless gas, liquefiable by a pressure of $6\frac{1}{2}$ atmospheres. It is so soluble in water as to be almost instantly absorbed, the water taking up several hundred times its volume of the gas.

NH_3 is also very soluble in alcohol, and the solution is a common article, called *spirits of hartshorn*, while the aqueous solution is known as Ammonia water.

Owing to its free solubility, NH_3 can not be collected over water, but inverted vessels may be filled with it in the same way as with Hydrogen (see fig. 24), since it is but little over one half as heavy as air (see its density).

The odor of Ammonia is exceedingly pungent, being the same as that given by preparations of *hartshorn*.*

Ill. 400. Lime being pulverized and mixed with Chlorid of Ammonium, NH_4Cl , also in powder, causes the pungent odor of NH_3 to be exhaled.

Ill. 401. Inverted bottles filled with NH_3 , by placing them over the straight tube of a flask containing the heated mixture of CaO and NH_4Cl .

Ill. 402. When a flask, full of gaseous NH_3 , has its neck dipped into water, the gas is dissolved, and the water enters, by atmospheric pressure, filling the flask.

* This term has originated from the former preparation of compounds of Ammonia from the horns of the *hart*.

248. Sources of NH_3 ? Where found? Causes which send it into the atmosphere?

249. Different artificial methods of production? Usual process to obtain NH_3 ? What are formed, and what are their symbols?

250. Color, form, and liquefiability, of NH_3 ? Solubility in water? Alcohol? Spirits of hartshorn? Collection over water? Why collected over air? Odor? How exhaled, 400? Inverted bottles filled, 401? Describe the solution, 402?

251. NH_3 does not support the burning of those substances which are combustible in air, nor is readily combustible itself, but under favorable circumstances it may be burned in O_2 with which it also forms an explosive mixture.

NH_3 is a powerfully caustic, corrosive, and alkaline substance, wholly irrespirable, capable of blistering the skin and like the alkalies of the Potassium group of metals, actively poisonous.

The proper antidote to all alkaline substances, in the stomach, is olive oil, or some other oily or fatty matter with which the alkali may combine and form a soap.

Ill. 403. A flask of gaseous NH_3 , being inverted with the mouth in red cabbage water; the water turns green as it rises in the flask, thus showing alkaline action.

Ill. 404. Reddened litmus water turned blue, and turmeric water browned by solution of NH_3 .

Ill. 405. Soaps formed with oil by solutions of KO ,— NaO , and NH_3 .

Ill. 406. An upright bottle of moist Chlorine and an inverted one of moist NH_3 , being placed mouth to mouth, and so held while reversed; there instantly occurs a flame with a profuse cloud of NH_4Cl .

252. Solutions and compounds of Ammonia are considerably employed in medicine and the arts. NH_3 is exhaled by guano and animal exuvia generally, and especially by that applied to the soil. It is so abundant in foul stables as to be a source of blindness and disease to domestic animals.

In nature it serves a very important purpose being considered to be the chief if not the only source of N . to the vegetable kingdom; so that vegetable and animal life are dependent upon it.

Next it is proper to notice the hypothetical substance termed

AMMONIUM, NH_4 .

253. This substance has never been isolated so that its existence is not positively established. It is known, however, that several substances contain its elements. It is presumed to have properties somewhat similar to those of metals.

One reason for this conclusion is, that when Mercury, under suitable conditions, is subjected to the action of certain compounds of Ammonia, it enlarges greatly, and its properties are changed; as though it were alloyed with some bulky metal. Therefore,

251. Relations of NH_3 to burning? Caustic and alkaline properties? Respiration? Action on the skin? Antidote to alkaline poisons and why? Red cabbage water, 403? Reddened litmus and turmeric water, 404? Soaps how formed, 405? Cl . and NH_3 , 406.

252. Uses of preparations of NH_3 ? Guano, etc.? Foul stables? What purpose does NH_3 serve in nature? Symbol and composition of Ammonium?

253. Isolation of NH_4 ? What is known of NH_4 ? Presumed properties? Reason?

the pasty compound thus formed has been termed *ammoniacal amalgam*.

Ill. 407. Mercury having been alloyed with about $\frac{1}{100}$ of Potassium is subjected to the action of a strong solution of Chlorid of Ammonium. In a short time the ammoniacal amalgam is formed.

The existence of such a body as NH_4 , is rendered probable, as before mentioned, by the fact that certain compounds contain its elements. In these compounds, too, it seems to act the part of a metal—for, like a metal, it seems to combine with Cl, to form a haloid salt, and also, like metals, it apparently unites with O.* and anhydrous Oxacids to form Oxyalts.

While, however, the existence of NH_4 is merely hypothetical, that of the salts referred to is perfectly certain, and their constitution, as now given, is established as the result of positive determination.

One of the *haloid* salts mentioned is the following :—

CHLORID OF AMMONIUM, NH_4Cl . *Eq.* $14+4\times 1+35.5=53.5$.

254. This is a native salt, but its chief present sources are the ammoniacal liquors, produced in the process for the manufacture of illuminating gas, or coal gas, and the decomposition of animal matters, such as horns, hoofs, bones, etc., at high temperatures. NH_4Cl is commonly called *sal-ammoniac*.

It is very soluble in water, is volatilized by heat, and crystallizes by sublimation or solution, in cubes and octahedrons.

255. It is extensively used for the preparation of the aqueous and alcoholic solutions of Ammonia; in medicine; in soldering tinware; and for various purposes in the arts.

Ill. 408. Specimen of sal-ammoniac.

THE CHLORID OF AMMONIUM AND PLATINUM, $\text{NH}_4\text{Cl}, \text{PtCl}_2$, has been referred to in Art. 83.

Ill. 409. Precipitation of $\text{NH}_4\text{Cl}, \text{PtCl}_2$, from solution of Chlorid of Platinum, PtCl_2 , by solution of Chlorid of Ammonium, NH_4Cl . The dried precipitate is a brownish yellow powder.

* This compound of NH_4 with O, is often called Oxyd of Ammonium.

Name of the substance formed by the action of a certain Ammoniacal compound on Mercury? Preparation of Ammoniacal amalgam, 407? How does NH_4 act the part of a metal in the compounds containing its elements? Certainty in reference to salts containing NH_4 ? What haloid salt of Ammonium is mentioned, and what is its symbol? Equivalent, how 53.5?

254. Sources of NH_4Cl ? Solubility and crystalline forms?

255. Uses of NH_4Cl ? Select the specimen of it, 408? Symbol of the Chlorid of Ammonium and Platinum? Preparation and appearance, 409?

OXYSALTS OF AMMONIUM.

256. These are the ordinary Ammonia salts. Being quite numerous, the principal ones only can receive attention.

SULPHATE OF AMMONIA, $\text{NH}_4\text{O}, \text{SO}_3$.

$$\text{Eq. } 14 + 4 \times 1 + 8, + 16 + 3 \times 8 = 66.$$

257. This salt is a volcanic product but is chiefly artificial. It is interesting as being one of the more fixed forms into which, by the use of Sulphuric acid and Sulphates, the Ammonia may be converted, that would otherwise escape, as a gas, from decomposing matters. It is a very soluble salt.

Ill. 410. Specimen of crystalized Sulphate of Ammonia.

NITRATE OF AMMONIA, $\text{NH}_4\text{O}, \text{NO}_5$.

$$\text{Eq. } 14 + 4 \times 1 + 8, + 14 + 5 \times 8 = 80.$$

258. This is the salt from which the Monoxyd of Nitrogen, NO , is generally prepared. It is a natural salt, found, in slight quantities, in rain water.

It is made artificially by neutralizing commercial Nitric acid with Carbonate of Ammonia. The solution, when properly evaporated, yields crystals which are six-sided prisms, like those of Nitrate of Potassa (saltpetre), which substance, $\text{NH}_4\text{O}, \text{NO}_5$, closely resembles.

$\text{NH}_4\text{O}, \text{NO}_5$, is a powerful fertilizer; but, at present, too costly to be extensively applied to soils.

Ill. 411. Neutralization of Nitric acid by Carbonate of Ammonia

Ill. 412. Crystalization of $\text{NH}_4\text{O}, \text{NO}_5$, by allowing a warm concentrated solution to cool.

Ill. 413. When crystals of $\text{NH}_4\text{O}, \text{NO}_5$, are laid on charcoal, on which a blowpipe flame is directed, they deflagrate rapidly by furnishing O , like saltpetre, to stimulate the burning of the coal.

259. PHOSPHATES OF AMMONIA occur in guano, constituting a portion of its most valuable elements, since they supply to the soil, both Phosphoric acid and Ammonia, two important ingredients.

256. Oxysalts of Ammonium? First one mentioned? Symbol and equivalent of Sulphate of Ammonia, and why?

[257. Sources and interest of $\text{NH}_4\text{O}, \text{SO}_3$? Solubility? Specimen, 410?]

258. Symbol and equivalent of Nitrate of Ammonia? Use? Natural source and artificial preparation? Shape of crystals? Resemblance? Fertilizer? Neutralization of Nitric acid, 411? Crystalization of the salt, 412? Charcoal, 413?

[259. Phosphates of Ammonia, source and use?]

PHOSPHATE OF AMMONIA AND SODA, $\text{NH}_4\text{O}, \text{NaO}, \text{HO}, \text{PO}_3$.

$$\text{Eq. } 14 + 4 \times 1 + 8, + 23 + 8, + 1 + 8, + 32 + 5 \times 8 = 138.*$$

260. This is a natural salt; but is produced artificially, and is of important use to mineralogists as a blowpipe reagent. It has been called *microcosmic salt*.

Ill. 414. Preparation of the Phosphate of Ammonia and Soda, by dissolving 16 parts of Chlorid of Ammonium in a small quantity of hot water, adding 100 parts of common crystalized Phosphate of Soda, boiling the solution very moderately, and then allowing the salt to crystalize as the solution cools.

261. There are several

CARBONATES OF AMMONIA,

But the most important is the *Sesquicarbonate*, $3\text{NH}_4\text{O}, 2\text{CO}_2$, which is very nearly the composition of *sal-volatile*, or the common commercial Carbonate; a substance extensively in use, and too much so, in cake making. *sal-volatile* is also called "*hartshorn salts*."

By exposure to air, *sal-volatile* loses Ammonia, and becomes a Bicarbonate of Ammonia, $\text{NH}_4\text{O}, \text{HO}, 2\text{CO}_2$.

Ill. 415. Specimen of *sal-volatile*.

262. These Oxysalts and the Chlorid of Ammonium are vaporized, or decomposed, at high temperatures.

They are also decomposed when heated with Lime, the Ammonia being liberated. In this way compounds of Ammonia may be detected, since the odor of the escaping gas is perfectly characteristic.

263. There are interesting compounds of dry NH_3 , with the anhydrous Oxacids; but their properties and reactions differ entirely from those just described. It is not within the plan of this work to notice them further.

* The learner should perfectly understand how the equivalent, 138, is made up, and should be able to explain all similar cases. For this purpose he may copy the formula, $14 + 4 \times 1 + 8$, etc., on the blackboard, and explain, that 14 is an equivalent of Nitrogen, or 14 parts of that substance by weight, 4×1 are four equivalents of Hydrogen, each weighing one, and so on,—and show how the total is 138.

[Symbol and equivalent of Phosphate of Ammonia and Soda, and why?]

[260. Use? Names? Preparation, 414?]

261. Carbonates of Ammonia? Most important one, and its symbol? *Sal-volatile*? Use? Other names? Effect of exposure?

262. Effect of heat on the salts of Ammonium? Of Lime and heat? Ammonia how detected?

[263. Compounds of dry NH_3 , with anhydrous Oxacids?]

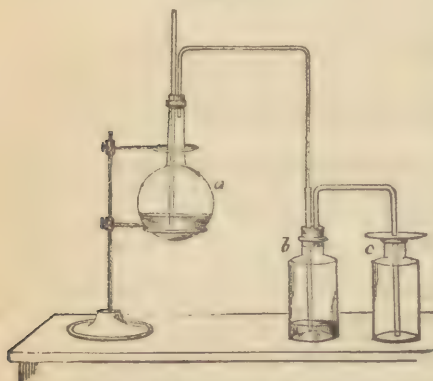
Next in order after the Oxysalts of Ammonia, comes the—

SULPHYDRATE OF AMMONIA,* $\text{NH}_4\text{S}, \text{HS}$.

$$\text{Eq. } 14 + 4 \times 1 + 16, + 1 + 16 = 51.$$

264. This important reagent, is of very frequent use in the analytic laboratory, as a precipitant of Metals.

Fig. 40.



Formation of Sulphydrate of Ammonia.

Ill. 416. $\text{NH}_4\text{S}, \text{HS}$. may be prepared by passing a very moderate stream of Sulphydric acid gas, evolved from Monosulphuret of Iron, FeS , and dilute Sulphuric acid in the flask, *a*, fig. 40, through the washing bottle, *b*, into Ammonia water in *c*, until the water is saturated. The bottle, *c*, must be kept cool as considerable heat is developed in the process.

Ill. 417. Precipitations in metallic solutions by means of $\text{NH}_4\text{S}, \text{HS}$.

265. Ammonia, NH_3 , the substance from which all these compounds take their name, is itself subject to some interesting trans-

formations. A part, or the whole of its Hydrogen may be replaced by a metal, or by a member of the Chlorine group, as the following examples illustrate :— (*See artificial alkaloids.*)

266. TRICHLORIC AMMONIA, NCl_3 , which has been called Chlorid of Nitrogen, is an oily-looking liquid, and one of the most violently explosive substances known. It results from the reactions between Chlorine and Chlorid of Ammonium.

It is too dangerous a substance to be prepared by any but the most cautious and experienced operators, and by them only in their private laboratories.

267. BINODIC AMMONIA, $\text{N}(\text{HI}_2)$, is a dark-colored, friable solid, similar to NCl_3 , in explosive properties; but somewhat less dangerous. It may be safely prepared in very small quantity as follows :—

* Sometimes called the double Sulphuret of Ammonium and Hydrogen.

What substance follows the Oxysalts of Ammonium? Symbol and equivalent of the Sulphydrate of Ammonia, and why?

264. Use of $\text{NH}_4\text{S}, \text{HS}$? Preparation, 416? Precipitations, 417?

[265. From what do the preceding salts take their name? To what transformations is NH_3 subject?

266. Symbol and properties of Trichloric Ammonia? Danger?

267. Symbol and properties of Binodic Ammonia?]

III. 418. A few grains of Iodine being covered with an ounce of Ammonia water, are rubbed with a pestle in a mortar, and left to stand half an hour. The liquid is then poured off, and the solid residue, distributed into smaller parcels on paper to dry. When nearly dry it explodes violently by the touch, or spontaneously if left alone.

268. MONOPOTASSIC AMMONIA, $N(H,K)$, is also a compound of the same type, illustrating that the H. may be replaced by a metal. Several others are known.

REVIEW.

269. The *simple substances*, as well as the *binary*, and the more *complex compounds*, have now received some attention. Many of the simples have been collected into groups, namely: Among the *non-metals*—

The *Chlorine Group*, containing I, Cl, Br, and F.

“ *Carbon* “ “ C, Si, and B.

And, among the *metals*—

The *Potassium Group*, or metals of the alkalis; as—
K, Na, Ca, &c.

“ *Aluminum* “ or metals of the earths; as—
Al, G, Y, &c.

“ *Iron* “ or metals of the strong bases; as—
Fe, Zn, Cu, Pb, &c.

“ *Tin* “ or metals of the weak bases; as— a
Sn, Bi, As, &c.; and—

“ *Platinum* “ or noble metals; as Ag, Au, and Pt.

For certain purposes, the simples might be more advantageously grouped, and many have been left altogether unassociated; but, for an elementary work, this plan has been preferred.

270. Then, among binary compounds, the following have been noticed:—

1st. The *Group of Hydracids*; as, the Chlorohydric, HCl .

2d. “ “ “ *Haloid Salts*; as, Iodid of Potassium, KI , and common salt.

3d. “ “ “ *Oxyds*; as, Oxyd of Zinc, ZnO .

Preparation, 418?

[268. Monopotassic Ammonia?]

269. What groups of non-metallic simples have been noticed? Examples of members of each group? Groups of metals?

270. What five groups of binary compounds and examples?

4th. The *Group of Sulphurets*; as, Sulphuret of Lead, PbS.

5th. “ “ “ *Anhydrous Oxacids*; as, Silicic, SiO_3 , and Sulphuric, SO_3 .

Then more complex compounds have followed; as, the

Hydrous Oxacids and Oxysalts; such as—

Hydrous Sulphuric acid, or Sulphate of Hydrogen, HO, SO_3 .

Sulphate of Iron, FeO, SO_3 .

Hydrous Nitric acid, HO, NO_5 .

Nitrate of Potassa, KO, NO_5 .

Then the *Sulphur salts*, as the Sulphydrate of Potassa, KS, HS , have been glanced at; and also the *Ammonia compounds*.

271. Having now attended, as far as circumstances will permit, to the substances belonging to *Inorganic Chemistry*, it will be next in order to review and to give a more general notice to those principles and laws which have come up incidentally, but which require a somewhat more extended consideration; as well as to notice others that are important, but, for the explanation of which, opportunity has not yet occurred.

To these matters, then, will be devoted the second part of the work.

Two groups of acids and salts? Answer: 1st, the Oxacids and salts; 2d, the Sulphacids and salts? Examples and symbols? What compounds followed the *sulphsalts* or Sulphur salts?

271. What business is next in order?

PART II.
GENERAL PRINCIPLES AND LAWS;
NOMENCLATURE;
AND THE
CHEMICAL RELATIONS
OF
ATTRACTION, ELECTRICITY, LIGHT, AND HEAT.

272. THE THREE PRINCIPAL OBJECTS of the science, namely, to disclose the constitution of substances, to describe the means of their decomposition and formation, and to notice their peculiar forms and properties, were referred to in Art. 3.

The FOUR CHIEF OPERATIONS, Combination, Decomposition, Solution, and Precipitation, were defined and illustrated in Arts. 4, 5, and 6.

These operations, as well as minor ones of a mechanical character, such as *pulverization, filtration, &c.*, are constantly employed in chemical research.

273. ANALYSIS is similar to Decomposition in meaning. Analysis, however, is more generally understood, in chemical language, to denote an investigation into the composition of a substance, by separating or separately changing its elements; so that they may be recognised, and in some cases their quantity determined.

When the object of the investigation is merely to ascertain *what substances* are present, it is called *Qualitative analysis*; but when the *weight* of the elements is also sought for, it is *Quantitative analysis*.

What departments of the subject are mentioned under PART II.?

272. What are the three principal objects of Chemistry? The four chief operations? [What minor operations are referred to?]

273. What is the meaning of *Analysis*? What is understood by chemical analysis? Qualitative? Quantitative?

274. A large share of the operative illustrations, previously referred to in this work, such as *precipitations, the evolution or isolation of simples, the formation of compounds, &c.*, are more or less connected with chemical analysis, and may be regarded as initiatory steps to Practical Chemistry.

275. Chemical analysis is said to be conducted in the *moist way*, when the substance under examination is subject to chemical or simple solution, in liquid acids or water; and in the *dry way*, when it is subject to fusion, by means of the heat of a blowpipe, lamp, or furnace.

Assaying is a kind of quantitative analysis, having for its object the determination of the quantity of *one or two only* of the substances which may form the matter under examination; as, finding how much Gold, Silver, or Platinum, exists in a commercial specimen, or coin.

Alkalimetry is the business of determining the quantity of alkali present in certain commercial articles, as in *potash, pearlsh, or soda-ash*.

Chlorimetry is the determination of the quantity of *Chlorine* present in such substances as *bleaching powder*.

Eudiometry is a term applied to processes for determining the comparative goodness of air, chiefly by the explosion of mixtures of air and H. The term has been extended to similar operations for other objects; but more accurate methods are now generally employed.

For a knowledge of chemical analysis in general, or of any of its more special objects, the student needs to apply to works devoted particularly to that department.

276. The CLASSIFICATION of all substances, as either simples or compounds, and the division of the simples into Metals and Non-Metals, were noticed in Arts. 7 and 8.

It was necessary, by the way, to refer to the following chemical principles:—

277. ALLOTROPISM. This is the capability of the *same substance* to exist in *different conditions*, in which it possesses *unlike* properties, as seen in respect to Chlorine (Art. 21) and Carbon (Art. 65).

DIMORPHISM. This is the capability of a substance to crystallize in *two totally unrelated forms*, as noticed in Art. 44, in connection with S.

274. What have been initiatory to Practical Chemistry?

275. Analysis in the *moist way*? *The dry*? Assaying?

[Alkalimetry? Chlorimetry? Eudiometry? Means of studying Analytical Chemistry?]

276. Substances how classified? Classification of simples?

277. What is allotropism, and what is said of it in the Article referred to? Dimorphism?

278. **DIFFUSIVE POWER OF GASES.** This is the tendency of gases to spread out into space, and to mingle with each other, referred to in Art. 79. It is a very important property, for by means of it the various elements of atmospheric air continue to be thoroughly mingled with each other, so that this great aërial ocean is nearly of uniform constitution throughout.

By this means, too, whatever vaporous impurities or poisonous gases and exhalations ordinarily escape into the atmosphere, are soon diluted and dispersed,—more rapidly than the contents of a bucket of discolored water cast into the liquid ocean.

Indeed, these impure matters are soon decomposed by their free contact with the O. of the air, and by the various chemical agencies to which they are subject.

It is very true, however, that in some localities, such as in miasmatic districts, and the filthy portions of crowded cities, the impure exhalations are in such large quantity, that even the powerfully diffusive tendencies and active chemical agencies of the atmosphere are insufficient to prevent their accumulation.

Attention may now be given to

CHEMICAL NOMENCLATURE.

279. By the *nomenclature* of a science, is meant its system of names.

The present chemical nomenclature, at least for inorganic substances, was devised by Lavoisier and his associates. It is remarkable for its simplicity, clearness, and precision; and may be considered as perfect, so long as the present theories maintain their ground.

280. Its general principles need to be thoroughly studied, so as to be rendered *perfectly familiar*; and when this is done,—though, to accomplish it, no great amount of labor is required—very much progress will have been made toward a mastery of the science; while, without a *critical knowledge* of the nomenclature, the student will frequently be at fault in using chemical terms, will always be liable to the most ridiculous blunders, and can never attain to a fair understanding of the subject.

278. Diffusive power of gases and its use? What become of impure exhalations into the atmosphere? Next subject?

279. What is *nomenclature*? Origin of the present chemical system of names? Excellence of the system?

280. Necessities and advantages of a familiar acquaintance with the nomenclature?

281. It has been thought advisable to defer a special notice of the nomenclature until the pupil should have acquired some familiarity with chemical names and their meaning. The principles now first distinctly stated will not appear novel; for the intelligent student will, in many cases, have noticed or anticipated them.

The CHIEF PRINCIPLES are as follows:—

282. *Each simple substance has a single word for its name, and therefore, any chemical name which is a simple word, may be presumed to be the name of a simple substance; as, Oxygen, Iron, &c.*

This does not apply, however, to animal and vegetable substances, nor to their derivatives; as, for example, Albumin, Starch, Morphine, Ammonia, and Cyanogen, are compounds.

It does not apply to terms not recognised as Chemical terms; such as, gypsum, salt, water, and copperas.

There is a special exception in case of the alkaline, and most of the earthy Oxyds; such as those of Potassium, Sodium, Aluminum, &c. (See Arts. 171, 174, 175), which, though compounds, are called Potassa, Soda, Alumina, &c.

283. The early names of such long known simple substances, as Iron, Sulphur, Silver, and Gold, have been retained; while, as must have been noticed, more recently discovered simples have received appropriate names; as, Chlorine, a yellowish green substance; Chromium, a substance remarkable for colors; and Platinum, from its original Spanish name, *platina*, little silver, that is, a substance found in small silvery grains.

284. *The names of compounds, with the exceptions already noticed, and also excepting acids, consist of two words, joined by of; as, Nitrate of Potassa, Chlorid of Iron.*

These two words, in names of binary compounds, are the names of the simples of which they consist, with a change in the termination of the first mentioned one.

*This changed termination, in the case of the first five simples, is id, or yd; as, Chlorid of Sodium, Oxyd of Zinc: and for the others, is uret; as, Sulphuret of Lead, Phosphuret of Calcium.**

285. *Those substances having a sour taste, and capable of reddening vegetable blues, etc., as noticed in Art. 32, are called acids.*

* Some Chemists use *id* where *uret* is here employed, as, Sulphid of Lead; and also the contrary; as, Chloruret of Silver.

[281. Why has the subject been deferred?]

282. Names of simples? Chemical names that are simple words? Exception in respect to animal and vegetable substances and examples? In respect to non-scientific terms? In respect to certain Oxyds?

[283. Origin and fitness of names of simples?]

284. Names of compounds and exceptions? Rule for the names of binaries? Change in termination? Examples?

285. What are acids?

Acids are arranged in classes, according to their characterizing elements,—and there are names for the several classes: for example: those mineral acids that contain O, are called Oxygen acids, or by abbreviation, Oxacids, Arts. 195, 198, 199; those containing H, and an element of the Chlorine group, are Hydracids, Arts. 135, 137; and those containing S, and not Oxygen, are Sulphur acids, or Sulphacids, Art. 244.

286. *The names of acids (except those of Oxacids), are compounded from the names of their elements; thus, Chlorine and Hydrogen form Chlorohydric acid,—Sulphur and Hydrogen, Sulphydric acid, &c.*

287. *The distinctive name of an acid always terminates, either in ic, or ous: the termination ic, being used to denote a higher ratio of the acidifying element than ous.*

Thus; Sulphuric acid is SO_3 , and Sulphurous acid is SO_2 : Oxygen being in this case regarded as the acidifying element.

288. *Since there may be more than two acids, formed of the same elements, it is necessary to have other means of distinguishing, beside the terminations ic and ous.*

These consist in the use of the prefixes, Hypo, denoting inferiority, and Hyper, denoting excess; the latter, by abbreviation being sometimes reduced to Per:

Thus; Sulphurous acid is SO_2 ; but Hyposulphurous acid, has less O. for the S, being S_2O_2 ; equal in ratio to SO. Also; Chloric acid is ClO_3 ; but Hyperchloric or Perchloric acid is ClO_7 .

289. *Those substances that are capable of combining with acids are called bases.*

The substances that are unequivocally basic have no acid properties.

Where several bases are formed from the same two elements, they are distinguished from each other by the prefixes, Mon, Bi, Ter, Di, etc., as hereafter noticed.

290. *The names of the Oxysalts, Sulphur salts, etc., consist of two words joined by of; the former word being the name of the acid with its termination changed from ic to ate, or from*

Classes of acids, and names of classes?

286. Names of acids, how formed, and exception? Examples?

287. Termination of the distinctive name of an acid? What is denoted by ic and ous? Example?

288. Why are other distinctions than ic, and ous necessary in names of acids? Meaning and use of Hypo and Hyper, and examples?

289. Bases? Unequivocally basic substances? Bases of the same elements, how distinguished?

290. Names of such salts as the Oxysalts and Sulphsalts consist of how many words, and how joined? The former word? Correspondence in change of termination?

ous to *ite*; and the latter word the unaltered name of the base.

Thus; Sulphuric acid, by combining with Magnesia, forms Sulphate of Magnesia; Hyposulphurous acid with Soda forms Hyposulphite of Soda; Sulpharsenic acid with Sulphuret of Potassium forms Sulpharsenate of Potassa.

291. *In salts of the metals of groups 3, 4, and 5, there is an abbreviation in the name of the base; the words, "Oxyd of," being omitted.*

Thus, when Sulphuric acid combines with Oxyd of Iron, FeO, as a base, the salt is called, simply, Sulphate of Iron, whereas it is in reality, Sulphate of Oxyd of Iron.

This abbreviation also applies to the names of the Sulphur salts, the words "Sulphuret of" being omitted; thus,—Sulphydrate of Ammonia, instead of Sulphydrate of Sulphuret of Ammonium.

292. Here the entire name is after the fashion of that of an Oxysalt of Ammonia, the termination of the final word being changed from *um* to *a*, as with alkaline and earthy Oxyds; the prefix *Sulph* being sufficient to distinguish the Sulphur salt. It is to be borne in mind that the base of a Sulphur salt is a Sulphuret just as that of an Oxysalt is an Oxyd.

293. *In the names of acids containing O, the rule for compounding the names of acids is not observed.*

Instead of saying *Oxysulphuric* acid, for the compound of one equivalent of S, and three of O, or *Oxycarbonic* acid, for that containing an equivalent of C. and two of O, the names are abbreviated to *Sulphuric* acid, and *Carbonic* acid simply.

This is done for brevity; as the acids containing O. are very numerous; hence:—

When the name of an acid is formed from that of one simple only, the acid is known to contain O; and to belong to the class of Oxacids.

This also applies to the Oxysalts; thus: instead of *Oxysulphate* of Soda, the name is simply Sulphate of Soda; while the names of all other salts are given, in this respect, in full; as *Sulphydrate of Ammonia*.

The latter word? Examples?

291. Names of ternary salts of certain groups of metals, how abbreviated? What is omitted? Example? Does this abbreviation apply to names of Sulphsalts? What is omitted? Example?

[292. Similarity in names of Oxysalts and Sulphsalts? Sufficient distinction between the two? Base of a Sulphsalt?]

293. In what case is the rule for making the names of acids compound, not observed? Examples? Reasons? How are Oxacids known, by their names, to be such? Examples showing the application of this abbreviation to names of Oxysalts? Of non-abbreviation in others?

294. The use of prefixes from *monos*, *sesqui*, *bis*, *ter*, and *pente*, signifying, respectively, single, one and a half, twice, thrice, and five, has been seen in the names of Monoxyd of Nitrogen, NO , Sesquiöxyd of Iron, Fe_2O_3 , Bichlorid of Mercury, HgCl_2 , Tersulphuret of Arsenic, AsS_3 , and Pentachlorid of Antimony, SbCl_5 .

These prefixes apply in case it is the first named element that is multiplied.

295. In those cases in which the second named element is multiplied, prefixes are formed from *dis*, *tris*, etc., signifying twice, and thrice; as, Dinöxyd of Copper, Cu_2O , and Triphosphate of Soda, $3\text{NaO}, \text{PO}_5$.

296. *Where several salts consist of the same acid, united with different bases; but the bases composed of the same elements; the salts are distinguished from each other, by prefixing to their names the distinguishing prefixes of the bases.*

Thus: Sulphuric acid, SO_3 , with Monöxyd of Iron, FeO , forms Monosulphate of Iron, FeO, SO_3 ; and the same acid with Sesquiöxyd of Iron, Fe_2O_3 , forms Sesquisulphate of Iron, $\text{Fe}_2\text{O}_3, 3\text{SO}_3$.

297. In naming compounds, it is the rule to place the name of the electro-negative element* first. According to this, it is necessary to say Chlorohydric and not Hydrochloric acid, and Öxyd of Hydrogen and not Hydruret of Oxygen; Chlorine and Oxygen being electro-negative substances, while Hydrogen is electro-positive.

For the same reason, in the names of Oxysalts, since the acid is the electro-negative element, its name is first mentioned in that of the salt.

Immediately following the subject of nomenclature is, properly, that of

* See Index, for *electro-positive and electro-negative substances*.

294. Derivation of prefixes from *monos*, *bis*, etc., and meaning? Examples of their use? In what case are the prefixes, just referred to, employed? Can you show, from the examples just given, that these prefixes apply to the first named element?

295. What is the derivation and meaning of the prefixes applied to the second named element? Examples and their explanation?

296. How are those salts distinguished from each other, which consist of the same acid combined with different bases of the same elements? Examples, and their application?

297. Which element is first mentioned in the name of a compound? Of the three substances, Cl, H, and O, which are electro-negative and which electro-positive? Why is the acid mentioned first in the name of an Oxy-salt?

CHEMICAL SYMBOLS.

298. A *symbol*, in Chemistry, is an abbreviation, by which the name of a substance is generally represented by a few only of the letters which ordinarily spell it.

In respect to the formation and use of symbols, it has doubtless been noticed that the symbol of a simple substance is generally its initial letter, in the form of a Roman capital.

When several simples have the same initial, an additional small letter is added, so far as is necessary, for the sake of distinction. Thus, the symbol of Boron is B;—of Bromine, Br;—and of Bismuth, Bi.

The symbols of compounds are composed of those of their elements. In those of the Oxysalts and Sulphsalts, the symbol of the acid is usually separated from that of the base by a comma or period—thus, KO, NO_5 .

299. It will be noticed that the symbols are written in an order the inverse of that of the names. Chlorid of Calcium, when symbolized, is CaCl ; and Sulphate of Magnesia is MgO, SO_3 ; the Magnesia being first in the symbol, but last in the name.

The symbols of compounds show, by their capital letters, the number of simples which they contain. Thus, PbO, CrO_3 , having four capitals, has four simple elements,—Lead, Oxygen, Chromium, and Oxygen; or, since the last is repeated, three different ones.

300. Symbols are employed in two different senses,—in a strict and a relatively definite sense; and also in a general and indefinite one.

In the sentence, "The ashes of plants generally contain S, P, and Fe, in a state of combination," the symbols are mere abbreviations, in a general way, for Sulphur, Phosphorus, and Iron, without any indication of the relative quantities of each; but in the sentence, "Soils consist chiefly of Al_2O_3 and SiO_2 , with admixtures of Carbonates, vegetable mould, and slight portions of Phosphates and other salts," the symbols are more definite. In the first compound, the symbol Al_2 signifies two equivalents of Aluminum, each equal to 13.7 parts by weight, combined with three equivalents of Oxygen, each equal to eight parts by weight.

SiO_2 , although no number is attached to the Si, implies one equivalent of Silicon, equal to 21.3 parts by weight, united to three equivalents of Oxygen.

What subject succeeds Nomenclature?

298. What is a chemical symbol? Symbols of a simple substance? When several simples have the same initial? Examples? Symbols of compounds? Separating point in symbols of complex salts? Example?

299. Inverse order for the symbols, and examples? The number of simples in a compound, how indicated in its symbol? Example?

[300. Two different senses in the use of symbols? Example in which the use of symbols is general and indefinite? Another, containing a relatively definite use? Example of a definite meaning for a symbol when no numeral is attached?]

It is always easy to perceive, by the connection in which they are used, whether the symbols signify equivalents or not: and when equivalents are implied, if no number is attached to the symbol, the number *one* is understood.

301. Since O. occurs in so many symbols of compounds, and is often found in these in a multiple ratio, a shorter abbreviation is made and considerably used, by substituting a point for O. On this system, Sulphate of Magnesia would be symbolized MgS . Further abbreviations are also in use, but it is unnecessary to introduce them here.

The use of symbols in Chemistry is of very great value. It is an immense saving in words, space, and time,—exhibiting, with clearness and precision, at a glance, what could not otherwise be so distinctly taught in whole sentences and pages.

A few unimportant variations from what has been inculcated in reference to names and symbols will be noticed in the different authors.

The use of such indefinite and inconvenient phrases as Protosulphuret, Deutochlorid, Tritoxyd, and Peroxyd, requires no explanation, and is very properly becoming obsolete.

It will be noticed that, contrary to the practice of many writers, the author has generally distinguished chemical names of substances by capital letters.

Since chemical names are strictly *proper names*, this practice is grammatically correct, and may be extended to all their derivatives; but more weighty reasons than any formal rule can afford are found in the necessity for some distinction between *correct scientific names* and mere *vulgar terms*, and for bringing out those names so prominently as to attract the learner's attention. This is done in other sciences, and there is no good reason why it should not be, in Chemistry.

The subjects of Nomenclature and Symbols seem to lead naturally to that of

CHEMICAL ATTRACTION, OR AFFINITY.

202. This special form of attraction is that which is exerted between two or more different substances, tending to cause them to unite, so as to form a new substance.

Thus, when Potassium is exposed to air, there is so strong an attraction between that metal and the gaseous O. of the air, that the two substances combine: the one losing its metallic and all its characteristic properties; the other its gaseous form, and likewise all its characteristics, and in their place is found a

[How is it known whether symbols signify equivalents? What is always understood in case equivalents are implied, but the symbol has no numeral?

301. What abbreviation is used for O, and why?

Advantages of the use of symbols? [Variation in reference to names and symbols among authors? Indefinite and inconvenient terms? Chemical names, how distinguished? Reasons?]

To what subjects do those of *nomenclature* and *symbols* seem to lead?

302. Definition of Chemical Attraction or Affinity? Example of the formation of a *new* substance by the action of affinity, and why now?

new substance, Potassa, KO, having none of the distinctive peculiarities of either of its elements.

Affinity, therefore, differs from all other forms of attraction in this, that it produces entirely new substances.

303. The word *combine*, and its derivatives, in chemical language, always refers to the idea of such a *chemical union*. *Combination* is, therefore, totally distinct in meaning from *mingling*, *mixture*, etc.

304. Chemical attraction is not an absolute and invariable force; but, like all other kinds of attraction, is affected by circumstances. Even Gravitation, the most general and unvarying form of attraction, is known to be affected by distance and by quantity of matter.

Chemical attraction is also affected by the same circumstances, and in addition by a great variety of others, such as temperature, the action of light, the electric condition, the state of combination of the substances in question, the influence of other attractions, the peculiar condition of the elements as to the nascent or the allotropic state, etc., etc.

Indeed, so variable is this wonderful influence, that its very existence has been questioned; but such a conclusion, on a full consideration of the case, must appear wholly unwarrantable.

The modifying influences of Electricity, Light, and Heat, will be referred to under their proper heads; those of other circumstances will now be briefly noticed.

305. Firstly, *State of combination*, or *one chemical attraction modifying another*. An example of this is seen in the two Oxys of Nitrogen. In one state of combination, as in the Monoxys, the O. and N. do not attract more O. In another state, as in the Binoxys, they do.

In some of these cases, one substance may seem to elect or choose between two others; as, where Carbonate of Soda is put into Sulphuric acid, the Soda gives up the Carbonic acid, and unites with the Sulphuric. Such cases are denominated *elective affinity*.

Doubly elective affinity is where there is a mutual decomposition between two compounds; as between Chlorid of Barium

Difference between affinity and other forms of attraction?

303. Use of the word *combine*, and its derivatives, in Chemistry? *Combination*, *mixture*, and *mingling*?

304. Variability of Affinity? The most unvarying kind of attraction? By what is gravitation affected? Chemical attraction? Modifying influences of Electricity, Light, and Heat, where referred to?

305. Example of the modifying influence of several chemical attractions? Elective affinity? Doubly elective affinity?

and Sulphate of Soda, to form Sulphate of Baryta and Chlorid of Sodium. The symbols exhibit the precise change: BaCl . and NaO, SO_3 give NaCl . and BaO, SO_3 .

306. Secondly, *Of the influence of other kinds of attraction*, many examples might be given. Thus—

If a heavy solution of Sulphuric acid should be placed above a lighter one of Potassa, but the two kept separate by some means, *gravity* would bring them together, and thus favor their combination, when the means of separation should be removed.

Density, which is the result of mechanical attraction, may exert an influence; as, where O. and H. are condensed in the pores of Platinum sponge.

307. *Solution*, and the *diffusive tendency* in gases, also the results of mechanical attraction, exert extensive influences. A very large share of the usual chemical changes are effected when the substances concerned are dissolved in water. The action of Chlorid of Barium and Sulphate of Soda in solution, just referred to, is an example.

Were it not for the *diffusive tendency*, the use of Chlorine as a disinfectant would be of little avail; for it could not otherwise be brought in contact with the substances mingled with the atmosphere, upon which it is designed to act.

308. Where a body is in a solid mass, as a piece of marble (also the result of mechanical attraction), the chemical action of a liquid, acid solution, will be much slower, though chiefly on account of the comparatively small surface exposed. Pulverization greatly increases the extent of surface in a solid, since each minute particle has a surface of its own.

III. 419. Equal weights of pulverized marble and of the same in mass, separately subjected to the action of Chlorohydric acid. In case of the powder, the action is nearly instantaneous.

Where substances react in consequence of fusion, it is partly the result of the mechanical liquid state, as well as of the temperature.

III. 420. A mixture of three parts of Nitrate of Potassa, two of Carbonate of Potassa, and one of Sulphur, explodes when fused.

309. The *nascent condition*,—that is, the condition of being in the act of liberation or formation,—has been seen (Art. 136) to affect chemical action.

Recent experiments on nascent Oxygen indicate that its properties are then more active, as it is claimed to be capable of spontaneously inflaming Ammonia, oxydizing Silver, etc.

The term *ozone* had previously been applied to what was considered an unusually active condition of Oxygen; brought about, however, generally, by other means than by its liberation from combination.

The active properties, the result of the *nascent state*, disappear in a moderately short time.

Allotropic conditions, however, which, as noticed in case of Chlorine and of Carbon, affect affinity, are more nearly, and sometimes entirely, permanent.

[306. Example of the action of gravity? Of what is density the result? Example of its influence?

307. Solution, and the diffusive tendency? Chemical changes in aqueous solution? Example? Example of the influence of the diffusive tendency?

308. Compact mass and pulverization, and why? Operation with marble, 419! Causes of reaction in case of fusion? Explosion in consequence of fusion, 420?

309. Definition of the *nascent state*? Example in Art. 136? *Nascent O?* *Ozone*? Permanency in connection with the nascent state? Permanency of *allotropism*?]

Chlorine, that has once been thoroughly exposed to light, retains the power of combining with H, or of decomposing water in the dark.

310. *Catalysis*, or decomposition by presence. This term is properly applied to a decomposition resulting from the presence of a substance which does not combine with either of the liberated elements. A good example is the decomposition of Binoxid of Hydrogen, HO_2 , by means of Gold-leaf; or even by Binoxid of Manganese, since the latter does not take any O. to itself, but also gives up its own.

311. Having referred to some of the modifying influences upon Affinity, of the circumstances of *catalysis*, *allotropism*, the *nascent state*, the influence of *mechanical attraction* in respect to *form* and *density*, *fusion*, *diffusion*, and *solution*, and the effects of *one Chemical Attraction upon another*,—it may be proper, before entering upon the chemical relations of Electricity, Light, and Heat, to notice some of the

GENERAL LAWS OF AFFINITY.

312. **FIRSTLY.** *The class of substances that unite with each other.* Simplex unite with simplex, and compounds with compounds. Thus, S. and C. combine to form Sulphuret of Carbon; but S. does not combine with Carbonic acid, nor Carbon with Sulphuric acid.

Also Carbonic acid, a compound, unites with Potassa, likewise a compound; and Sulphuric acid combines with Potassa.

In Organic Chemistry, it will be seen, however, that some compounds seem to possess the properties of simplex, being capable of uniting with simplex.

313. *There is generally a correspondence in the classes of compounds that unite with each other:* thus, Oxacids unite with Oxyds; Sulphacids with Sulphurets; Chlorids with other Chlorids, as in the double Chlorid of Ammonium and Platinum; and Sulphates with other Sulphates as in the alums.

There are cases where this correspondence is not maintained, but the rule predominates.

SECONDLY. *Nature of the substances formed by different combinations of the same elements.*

[Examples.

310. Definition of *Catalysis*? Proper application of the term? Examples?]

311. What modifying influences upon Affinity have now been referred to? What subject immediately follows, and what succeeds that?

312. Under the head of *general laws of affinity*, what is first referred to? What unite with simplex, and what with compounds? Examples? Exception in Organic Chemistry?

313. Classes of compounds that combine with each other? Examples?

Where the same simple combines with O, for example, to form both *bases and acids*; the *acids* are those that have the highest share of O; while the *bases* have the lowest; as noticed, Art. 150, in reference to the compounds of Fe. and O; but the acids and bases gradually shade in toward each other.

THIRDLY. *The ratios in which substances unite.*

314. There are four laws in respect to ratios of combination, namely:—

- 1st, *the Law of Definite Ratios* ;*
- 2d, *the Law of Equivalent Ratios* ;
- 3d, *the Law of Multiple Ratios* ; and
- 4th, *the Law of Ratios of Compounds*.

315. Firstly, THE LAW OF DEFINITE RATIOS. This is, that a chemical substance always consists of the same elements, combined in a definite and invariable ratio. It is illustrated by every case of chemical combination; and is, indeed, so *characteristic*, as to serve as one means of distinguishing *true chemical combination*, from mere mixture, or that sort of union which is seen as the result of a sort of cohesion in simple solution.

To illustrate the law of Definite Ratios, we may take, for example, the combination of O. and H, to form water. Now, precisely eight pounds of O. unite with one pound of H; and though these substances may combine with each other to any extent, yet in case of direct combination, there will always be, in the compound formed, eight times as much of the former, as of the latter; and any excess of either remains uncombined. This may roughly be illustrated as follows:—

Ill. 421. Repeated explosions of mixtures of O. and H, in Ure's Eudiometer, fig. 41, by the electric spark, the ratios every time being previously known by measurement (Art. 162), which, in this case, is more

Fig. 41.



Ure's Eudiometer.

* In reference to the use of the term *ratio*, instead of the more common term, "proportion," it is only necessary to say, that a proper regard for the just meaning of words, as well as for uniformity in chemical and in mathematical phrase, seems to require it.

What is said of the nature of the substances formed by different combinations of the same elements? Examples?

314. How many laws in respect to combining ratios? Name the four laws of combination?

315. What is the law of *definite ratios*? By what illustrated? The characteristic nature of this law serves what purpose?

[Illustrate the law of definite ratios?] Result of exploding mixtures of O. and H, containing two measures of H, to one of O, 421?

convenient than weighing, are always followed, when the ratio is two of H, to one of O, by measure, by the total conversion of the gas into water; there being no gaseous residue. But in case the mixture is not in this ratio, there is always a residue, and of the gas only that is in excess.*

316. Secondly, THE LAW OF EQUIVALENT RATIOS. This is, that the simplest definite quantities in which various simple substances combine, are generally of equal values.

Again take an example:†

Eight pounds of O. are united with one pound of H, in water. Also, six pounds of C. are combined with one pound of H, in Olefiant gas: now, in what ratio may O. and C. combine with each other; that is, suppose C. is combined with O, instead of H. being combined with O; how much of the C. will be equal in value, or be *equivalent* to one pound of H.

We might suppose, beforehand, from the composition of Olefiant gas, that six pounds of C. would be required; and this is really the case, since Carbonic Oxyd, consists of eight pounds of O. to six of C.

Hence it is said, that in combination, six of C, one of H, and even eight of O, are equivalent‡ to each other, and these are equivalent ratios.

317. Thirdly, THE LAW OF MULTIPLE RATIOS. This is, that where the same two substances form several different compounds, the ratios, in the more complex compounds are *multiples*, or may be produced by multiplications of the ratio in the simplest.

The compounds of O. and N, with each other, are, perhaps, the best illustration of this law:

	Equivalents.	Parts by weight.
		O. N.
These are,— <i>Monoxyd of Nitrogen</i> ,	NO.	or 8 to 14.
<i>Binoxyd of Nitrogen</i> ,	NO ₂	or 16 to 14.
<i>Nitrous Acid</i> ,	NO ₃	or 24 to 14.
<i>Hyponitric Acid</i> ,	NO ₄	or 32 to 14.
and <i>Nitric Acid</i> ,	NO ₅	or 40 to 14.

In the ratios, or fractions, $\frac{8}{14}$, $\frac{16}{14}$, $\frac{24}{14}$, $\frac{32}{14}$, $\frac{40}{14}$, it is evident that all the following ones are multiples of the first.

* The fact that there are Definite Ratios, by volume as well as by weight, in chemical combination, it has been judged advisable to only notice incidentally.

† Some other examples, better illustrating at the same time, replacement and isomorphism, might, perhaps, be taken; but, since there is nothing incorrect in this, it will serve the present purpose better, on account of its simplicity.

‡ Hence arises the use of the phrases, *equivalent numbers*, *chemical equivalents*, or simply *equivalents*, applied to the numerals used in representing the combining ratios.

316. What is the Law of equivalent ratios? [Example?]

317. The Law of multiple ratios? Example?

318. Fourthly, THE LAW OF RATIOS OF COMPOUNDS. This is, that the combination ratios of compounds consist of the sums of the equivalent numbers of their elements.

For example:—

Water is composed of 1 pound of H+8lbs. of O= 9

Lime “ “ “ 20 “ Ca+8lbs. of O=28

Therefore water and Lime combine in the ratio of 9 to 28; or, 9 pounds of water combine with 28 of Lime to form 37 of Hydrate of Lime.

TABLE OF THE SYMBOLS AND EQUIVALENTS
OF THE SIMPLE SUBSTANCES.*

Aluminum	Al	13.67	Molybdenum	Mo	46.00
Antimony	Sb	129.00	Nickel	Ni	29.6
Arsenic	As	75.00	Niobium	Nb	
Barium	Ba	68.64	Nitrogen	N	14.00
Bismuth	Bi	212.86	Norium	No	
Boron	B	10.9	Osmium	Os	99.6
Bromine	Br	80.00	Oxygen	O	8.00
Cadmium	Cd	56.00	Palladium	Pd	53.3
Calcium	Ca	20.00	Phosphorus	P	32.00
Carbon	C	6.00	Platinum	Pt	98.7
Cerium	Ce	46.00	Potassium	K	39.2
Chlorine	Cl	35.5	Rhodium	R	52.2
Chromium	Cr	26.7	Ruthenium	Rt	52.2
Cobalt	Co	29.5	Selenium	Se	40.00
Columbium	Ta	184.59	Silicon	Si	21.3
Copper	Cu	31.7	Silver	Ag	108.00
Didymium	D	31.66	Sodium	Na	23.00
Erbium	E		Strontium	Sr	44.00
Fluorine	F	19.00	Sulphur	S	16.00
Glucinum	G	26.5	Tellurium	Te	64.00
Gold	Au	98.5	Terbium	Tb	
Hydrogen	H	1.00	Thorium	Th	59.6
Iodine	I	127.00	Tin	Sn	58.00
Iridium	Ir	99.00	Titanium	Ti	25.00
Iron	Fe	28.00	Tungsten	W	95.00
Lanthanum	Ln	36.00	Uranium	U	60.00
Lead	Pb	103.5	Vanadium	V	68.6
Lithium	L	6.5	Yttrium	Y	32.2
Magnesium	Mg	12.1	Zinc	Zn	32.6
Manganese	Mn	28.00	Zirconium	Zr	34.00
Mercury	Hg	100.07			

* Chemical investigations are continually increasing the accuracy of the equivalent numbers; it is believed that those given in this table are generally correct for the present time.

318. The Law of ratios of compounds? Example?

319. What are given in the table in this article?

In addition, it may be remarked, that the law of multiple ratios applies to compounds, as well as to simples; as is illustrated, for example, by the monobasic, bibasic, and tribasic Phosphates, Art. 224.

Peculiarities in reference to the constitution of certain compounds may be noticed, as in case of Sesquiöxysalts. Thus:—

Sesquisulphate of Alumina, $Al_2O_3, 3SO_3$, and

Sesquisulphate of Iron, $Fe_2O_3, 3SO_3$,

contain 3 *Eq.* of O. in the base, 3 also in the acid, and 3 *Eq.* of acid combined with one of base. These peculiarities are interesting, and the study of all such cases tends to extend the theory of the science.

319. From the preceding table of the equivalent numbers of simple substances, the equivalents of all compounds may be computed.

Before leaving the subject of Attraction, it will be well to notice a special form of it, having some resemblances to affinity.

It may be called

CRYSTALLOGENIC ATTRACTION,

Since it determines the

SHAPES OF CRYSTALS.

320. By *crystallogenic attraction*, is meant that force by which the particles of a substance tend toward a symmetrical arrangement, in the solid condition, so as to form crystals.

This form of attraction, like affinity, varies with different substances, and is modified by circumstances, giving very great diversity in the forms of crystals.

It is found, however, that all these diverse forms are modifications of a few primary shapes, 14 in number, comprising 10 *prisms*, 3 *octahedrons*, and a *dodecahedron*.

321. A **PRISM** is a solid, having, beside its bases or ends, three or more plane faces, separated from each other by parallel edges. The *ten prisms referred to are as follows*:—

1. The Cube, having six equal square faces, fig. 42.
2. The Right Square Prism, fig. 43. This has a square base, but a variable height. Standing perpendicularly on its base it is said to be *right* or erect.
3. The Right Rectangular Prism, fig. 44. This has a base that is *rectangular*, that is, square cornered, but longer than it is wide. This prism is of variable height, and standing perpendicularly on its base, is also a right prism.
4. The Right Rhombic Prism, fig. 45. The base of this is a *rhombus*, an equally four-sided figure, with two acute, and two obtuse angles. This prism stands perpendicularly, or erect upon its base. It varies in its height, and in the size of its basic angles.

[The Law of multiple ratios, and compounds? Sesquiöxyds? Use of such cases?] What form of attraction is next treated? Why called crystallogenic attraction?

[320. Variability? What diversity is thus caused? From how many and what primitive shapes are all crystalline modifications derived?

321. Definition of a *prism*? First prism, and description? Second prism? Describe the right rectangular prism? The right rhombic?]

5. The Right Rhomboidal Prism, fig. 46. The base of this is a *rhomboid*, a four-sided figure, having its length unequal to its breadth, and with two acute and two obtuse angles. This prism is erect, and varies in height, in its basic angles, etc.

6. The Oblique Rectangular Prism, fig. 47. The base of this is rectangular, but it is longer than it is wide. This prism does not stand erect upon its base, but inclines, or leans over, and is, therefore, said to be *oblique*. This prism may vary in inclination, in length, and in the ratio of length to breadth in its base.

7. The Oblique Rhombic Prism, fig. 48. This is like the right rhombic, except that it is not erect. Its possible variations are readily seen.

8. The Oblique Rhomboidal Prism, fig. 49, is like the *Right* Rhomboidal, but it inclines.

9. The Hexagonal Prism, fig. 50. The base of this is a regular Hexagon, a figure having six equal sides and angles. Its height is variable.

10. The Rhombohedron, fig. 51. This is a rhombic prism, having its six faces all equal and each face a rhombus.

322. An OCTAHEDRON is a solid having eight faces. The three octahedrons referred to are as follows:—

1. The Regular Octahedron, fig. 52. Each of the faces of this, is an equilateral triangle,—that is, a figure having three equal sides. The faces are all equal, and so are the edges.

2. The Square Octahedron, fig. 53. This has a base that is a square. Each of its faces is an isosceles triangle,—that is, a triangle having only two equal sides. The height of this octahedron is variable.

3. The Rhombic Octahedron, fig. 54. The base of this is a rhombus, its height is variable.

Beside the ten prisms, and the three octahedrons, there is a *dodecahedron*, that is, a twelve-faced solid. The one referred to, as one of the fourteen primary forms, is the RHOMBIC DODECAHEDRON, fig. 55, which has a rhombus for each of its twelve faces. These faces are all equal to each other.

323. The classification of these fourteen solids into *prisms*, *octahedrons*, and a *dodecahedron*, is a Geometric classification, here introduced merely to facilitate the explanation of their respective forms, and to assist in their remembrance.

In a correct *crystallogenic classification*, these fourteen primary forms, and their modifications, constitute *seven systems*; namely:—1st, the Monometric; 2d, the Dimetric; 3d, the Trimetric; 4th, the Monoclinic; 5th, the Diclinic; 6th, the Triclinic; and 7th, the Hexagonal, or Rhombohedral.

324. 1st. The Monometric system of crystals.

The term *monometric* signifies, *having one measure*.

[Right rhomboidal? Can you draw a square, a rectangle, a rhombus, and a rhomboid, on the blackboard? How do all these *right* prisms stand? Which vary, and how? Describe the oblique rectangular prism? Oblique rhombic? Oblique rhomboidal? How do the oblique prisms stand? Hexagonal prism? The rhombohedron?

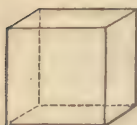
322. Define an octahedron? The regular octahedron? Square octahedron? Rhombic octahedron? What is there beside the ten prisms, and the three octahedrons? What is a dodecahedron? A rhombic dodecahedron?

323. Geometric classification and use? How many systems, and their names on a crystallogenic classification?

324. Define *monometric*?

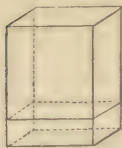
TEN PRISMS.

Fig. 42.



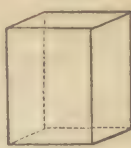
Cube.

Fig. 43.



Right Square Prism.

Fig. 44.



Right Rectangular Prism.

Fig. 47.

Fig. 45.



Right Rhombic Prism.

Fig. 46.



Right Rhomboidal Prism.



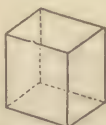
Oblique Rectangular Prism.

Fig. 48.



Oblique Rhombic P.

Fig. 49.



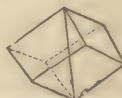
Ob. Rhomboidal P.

Fig. 50.



Hexagonal Prism.

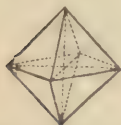
Fig. 51.



Rhombohedron

THREE OCTAHEDRONS.

Fig. 52.



Regular Octahedron.

Fig. 53.



Square Octahedron.

Fig. 54.



Rhombic Octahedron.

DODECAHEDRON.

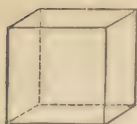
Fig. 55.



Rhombic Dodecahedron.

MONOMETRIC SYSTEM.

Fig. 42.



Cube.

Fig. 52.



Regular Octahedron.

Fig. 55.



Rhombic Dodecahedron.

DIMETRIC.

Fig. 43.



Right Square Prism.

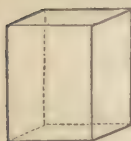
Fig. 53.



Square Octahedron.

TRIMETRIC.

Fig. 44.



Right Rectangular Prism.

Fig. 45.



Right Rhombic Prism.

Fig. 54.



Rhombic Octahedron.

DICLINIC.

Fig. 47.



MONOCLINIC.

Fig. 48.



Oblique Rhombic P.

Fig. 46.

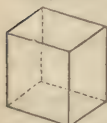


Right Rhomboidal Prism.

Oblique Rectangular Prism.

TRICLINIC.

Fig. 49.



Oblique Rhomboidal Prism.

HEXAGONAL.

Fig. 50.



Hexagonal Prism.

Fig. 51.



Rhombohedron.

The primary forms belonging to this system are the *cube*, fig. 42, *regular octahedron*, fig. 52, and *rhombic dodecahedron*, fig. 55. These are classed together for two reasons.

Firstly. In each of these solids, the length, breadth, and height, are all equal to each other.

Secondly. Each of these three forms may readily pass into either of the others.*

Common salt, garnet, diamond, and galena, crystalize in the primary forms of this system.

325. 2d. The *Dimetric System*, or system of two different measures. The primaries of this system have their length and breadth equal to each other, but they vary in height. They are the *right square prism*, fig. 43, and the *square octahedron*, fig. 53.

As in the first system, one form may change to the other. They are, therefore, classified together, like the members of the remaining systems, for reasons similar to those referred to under the monometric class. The crystals of Monochlorid of Mercury belong to this form.

3d. The *Trimetric System*, or system having three different measures, the length, breadth and height being all unequal.

The primaries of this system are the *right rectangular prism*, fig. 44, the *right rhombic prism*, fig. 45, and the *rhombic octahedron*, fig. 54. Sulphur and Sulphate of Zinc form crystals belonging here.

326. 4th. The *Monoclinic System*, or system of one inclination. The primaries which *lean in one direction* are the *right rhomboidal prism*, fig. 46, and the *oblique rhombic prism*, fig. 48. Sulphate of Soda forms crystals belonging to this system.

5th. The *Diclinic System*, or system of two inclinations. The primary is an *oblique rectangular prism*, fig. 47.

327. 6th. The *Triclinic System*, or system of three inclinations, has for a primary form; the *oblique rhomboidal prism*, fig. 49. Sulphate of Copper forms crystals of this system.

* If the solid angles or corners of the cube, are equally cut away, inclining the knife on each angle equally to the adjacent faces; and this is continued until the faces of the cube disappear, the solid is converted into the regular octahedron.

Also, by cutting off, in a similar way, the twelve edges of a cube, it becomes the rhombic dodecahedron, and by such means each of the three may be converted into either of the others.

The teacher, or the learner, can do this readily, by cutting a neat cube of convenient size, say an inch and a half, or two inches in diameter, out of common hard soap, and then proceeding to cut off the corners; and so with all other cases indicated.

Models of the fourteen forms may be cut out of chalk, and by varnishing they become quite firm.

[Primaries of the monometric system? Reasons why? Explain how the cube, &c., may pass into each other?

325. Meaning of dimetric system? Members of the *dimetric* system? Why? Define the *trimetric* system, and give its members? What crystalize in this system?

326. The *monoclinic* system? Its members? What crystalizes here? *Diclinic*, and member?

327. The *triclinic* system and member? What crystalizes here?]

7th. *The Hexagonal, or rhombohedral System*, includes the *regular hexagonal prism*, fig. 50, and the *rhombodron*, fig. 51. Carbonate of Lime forms crystals of this system.

328. As has already been noticed, whenever a substance crystallizes in the forms of two different systems, it is said to be *dimorphous*. Some substances are *trimorphous*, or crystallize in three different systems. Whenever the different crystals of a substance belong to more than one system, the substance is said to be *polymorphous*; so that polymorphism includes dimorphism, trimorphism, etc.

329. Substances that are not polymorphous may crystallize in the different primary forms of the same system. Thus, Fluorid of Calcium is found both in cubes and in regular octahedrons.

The cubes or the octahedrons may vary in size; but the form is always a cube, that is, has all its faces equal squares; or, always a regular octahedron, having all its faces equal to each other, all being equilateral triangles.

III. 422. Models of the fourteen primary crystalline forms.

330. There may, however, be many modifications of these primary forms; since, as the crystal increases in size, one or more planes may replace an edge or a solid angle; and thus give rise, in the first system, to solids of 12, 24, 48, or more faces; and especially, as the variety is increased by the different stages of these modifications, or by the modification occurring on only a portion of the angles or edges.

However the size, or in prisms other than the cube, the length of the crystal may vary, its angles are always constant, or very nearly so, for the same substance: and often by this constancy in the angle the substance is recognised.

331. It frequently happens, that different chemical substances crystallize in the same form; and even with the angles nearly or quite the same. Such different substances are said to be *isomorphous*.

The Carbonates of Lime, Magnesia, Iron, and Zinc, all form Rhombohedric crystals, of which the angles vary but a trifle; and these substances are therefore examples of isomorphism.

Owing to the isomorphism of certain bases, such as the Oxyds of the Carbonates just referred to; these often replace each other in natural crystals to a considerable extent, so that crystals of the same shape may contain various substances.

The laws of crystalization are very interesting and important, but space does not permit their further elucidation now.

THE ATOMIC THEORY.

332. The word atom signifies that which can not be cut or divided.

By the *atomic theory* is understood: *firstly, the supposition*, that a mass of a simple substance, as Oxygen, for example, is made up of great numbers of almost infinitesimal particles which are themselves wholly indivisible, and are called *ultimate atoms*.

[Hexagonal system and members? Example?

328. Dimorphous substances? Trimorphous? Polymorphous?

329. Crystalization in the different forms of the same system? Variation in cubes and octahedrons?

330. Explain *how* many modifications may arise in the same system. Constancy of the angles?

331. Isomorphous substances? Examples? Variation in the composition of crystals of the same shape?

332. Definition of atom? First supposition of the atomic theory?]

Secondly. That a compound, such as water, for example, consists also of atoms; but that these atoms are compound, each one consisting of an ultimate atom of O. and one also of H; the compound atom of water being properly an atom, that is indivisible, *so long as it is water*; but decomposable into an atom of O. and one of H.

Thirdly. It is further supposed, that all atoms of the same substance are always equal to themselves and to each other in size and weight.

Fourthly. It is supposed also, that an atom of O. is always eight times as heavy and one half as large, as an atom of H; that an atom of C. is six times as heavy as one of H; and generally, that atoms of all substances have the same ratio to each other, in weight and in volume, as their known chemical equivalents for weight and volume respectively.

333. While, *this is all theory*, or supposition; it is very ingenious, plausible, and even useful; for it assists us to give some explanation of well established facts, that can not at present be better explained. And while it may never be demonstrated: it is curious to inquire, how we shall be able to carry it as far as the *wave theory of light* has been carried. The length of a wave of red light, and the number of times per second that it vibrates, have been estimated. How shall we estimate the weight and the bulk of an atom of Oxygen? We may estimate the *shape* of an atom of diamond; but how shall we get at its weight?

THE CHEMICAL RELATIONS OF ELECTRICITY.

1st.—ITS CHEMICAL SOURCES.

334. THERE is a development of electric excitement in connection with every Chemical change; but in order to *apply* the electric influence thus developed, some special apparatus or arrangement for the purpose, generally known as a Galvanic battery * or a Voltaic circuit must be employed.

There is an extensive variety of Voltaic arrangements; but a single one will serve to illustrate their general principles. The modification of Grove's Battery which is in common use may, on account of its convenience and energy, be selected.



335. This battery (fig. 56), consists of one or more glass cups, as *d*, having within it a hollow Zinc cylinder *b*, considerably smaller than the inner diameter of the cup; and on the inside of the cylindri-

* Galvani and Volta were the earliest experimenters in the development of electricity by Chemical action. Hence Galvanism and Voltaic Electricity are terms sometimes applied to electricity thus developed.

Second, third, and fourth suppositions of the *atomic theory*?

333. Advantage of the *atomic theory*? Prospective extent? What subject follows the *atomic theory*? First part of this subject?

334. Electricity and chemical action? Apparatus why necessary and what called? Galvani and Volta? Variety of Voltaic arrangements? Which is selected for description?

335. The parts of a battery cup?

cal Zinc which is amalgamated, in order to equalize and moderate the chemical action, a cup of porous earthen ware, *c*, containing a slip of Platinum foil.

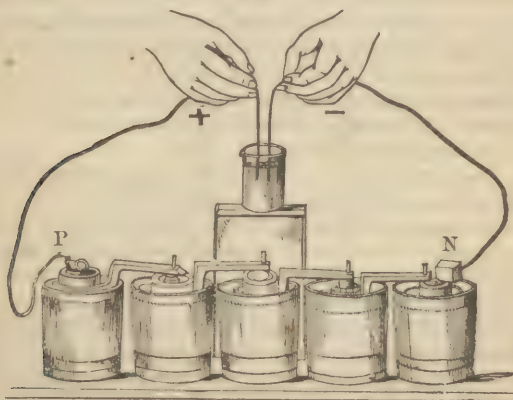
The inside porous cup is filled with commercial Nitric acid; and the space outside of this cup, with Sulphuric acid mixed with from ten to forty volumes of Water.

To complete the arrangement, a copper wire, about $\frac{1}{16}$ of an inch in diameter, and of convenient length, say several feet, connects the Zinc with a small part of the Platinum slip that is above the acid.

336. Instead of a single cup, several, the number being increased to 5, 10, 100,* or more, according to the intensity required, may be joined in a row, in which case each zinc cylinder has the Platinum slip of the next cup, attached to a lateral arm as in *a*, fig. 56.

The cups having been filled with the acids and all placed in position, as in fig. 57, the Zinc arms connecting the Zn. of

Fig. 57.



Grove Battery, Decompositions.

one cup with the Pt. of the next; the previously unconnected Zn, at one termination of the row is then joined to the termina-

* The operations hereafter described, *Ills.* 423 to 432, may be performed with from two to five cups.

With what is the porous cup filled? The space outside of it? Arrangement of the Wire?

336. How many cups are used? How joined? Ends of the row how connected?

ting Pt, of the other extremity, by a wire as before; the size of the wire being increased with the number of the cups.

337. Here then is a complete *circuit* of metallic and liquid *electric conductors*, starting from the point P, where the wire is joined to the Pt; following the wire around to the Zn. at N; then, by means of the acids which permeate the porous cup, to the Pt. slip; from that by the Zn. arm to the next cup, and so on to the starting point at P.

This circuit must be perfectly complete throughout; being thoroughly connected everywhere; and when this is the case, there is a constant electric action extending around and through the circuit.

338. To subject a body to the direct action of the electricity thus developed, the wire is cut, at a point remote from the cups, and the body is interposed.

The cut termination of the wire, on the side toward where it is joined to the Pt. at P, is the positive pole of the battery +, the other cut termination is the negative pole —. Any point on the side P. is positive in relation to a corresponding point on the other side; and P. is the positive end of the battery:—N. the negative end.*

339. The chemical changes in this battery are as follows; its elements being Platinum, Pt,—Zinc, Zn,—Water, HO,—Sulphuric acid, SO_3 ,—and Nitric acid, NO_5 .

HO is decomposed; the O and Zn, uniting to form ZnO , with which SO_3 forms Sulphate of Zinc, $\text{ZnO}.\text{SO}_3$. The liberated H. takes O. from the NO_5 , to re-form Water.

In this battery then the Pt. is unaffected and the quantity of water is constant; while the Zn, as well as the acids, are changed to other conditions.

The positive wire, is that connected *apparently* with the Pt, the unchanging metal; while the negative wire is attached to the Zn, the metal that corrodes; but since the terminal metals are not active elements of the series, the positive wire is actually connected with the Zn, and the negative with the Pt.

* Faraday has named the positive pole, the *anode* and the negative one the *cathode*.

337. Describe the continuous circuit? Completeness and Connection? Electric action when and where?

338. Bodies how subjected to the action of the battery? Positive Pole? Negative? + and — ends of the battery?

339. What are the elements of the Grove battery? Their chemical changes? Which is unaffected? Which is constant? Which are changed? Which pole is that connected with the unaffected metal? Which wire in all batteries is positive and which negative?

This is seen in a single cup, and holds true in all Galvanic arrangements; no matter what the metals or the corrosive substances may be. That is; the wire *in reality* attached to the corroded metal, is positive; and the other is negative.

340. The electricity of this and other batteries, is capable of producing all the effects which electricity from any source can produce.

Its *physical effects*, as the development of attraction and repulsion, heat, light, induced electricity, and magnetism, belong to the subject of Physics. Its chemical effects are now to be considered.

2d.—CHEMICAL EFFECTS OF ELECTRICITY.

341. These are the production of Decomposition and Combination; and the Galvanic battery is extensively employed for decompositions.

Decomposition by the battery, is termed *electro-chemical decomposition*, and also *electrolysis*. The substance to be decomposed is called the *electrolyte*; and, when the decomposition is completed, it is said to have been electrolyzed.

342. It is generally necessary for the electrolyte to be in the *liquid state*; and therefore, solids to be decomposed, are dissolved, or sometimes fused. Gases, also, are dissolved.

The electrolyte is generally placed in a glass vessel; and the poles of the battery are immersed in it, as near as possible to each other; but without actual contact, as this would prevent the substance from being acted upon.

343. Immediately on the immersion of the poles of the battery, the effects, whatever they may be, begin to appear.

Various arrangements are employed to render these effects more evident; since, without a battery of *very great power*, only extremely minute results are perceived; and this is not surprising when it is considered, that in electrolysis, one force is directly opposed to another; the chemical attraction, the original force which maintains the union of the elements of the compound, and is the cause of its stability, is to be directly overcome by the electric force.

340. Effects of the electricity of this battery? Physical effects?

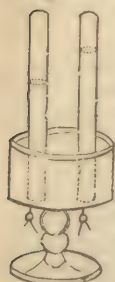
341. Chemical effects of the battery? Different terms for decomposition by electricity? Terms for the substances to be decomposed? Electrolyzed?

342. Necessary state of the electrolyte? Solids? The liquid how arranged? Poles?

343. Consequence of the immersion of the poles? Certain arrangements why required? Effects why so minute? Which are the opposing forces?

It has been estimated, that the quantity of electricity necessary to decompose a single grain of water, is as great as is discharged in a powerful flash of lightning, in a thunder storm.

Fig. 58.



Collection of O.
and H. in the
Electrolysis
of Water.

Ill. 423. Water, somewhat acidulated with Sulphuric acid, is decomposed; its O. appearing at the positive pole, and its H. at the negative.

Ill. 424. The poles being surrounded, as in fig. 58, with small glass cells or tubes, the gases are separately collected, and may be tested by the action of the O. on burning, and the inflammation of the H; or, they may be mixed and exploded by the application of flame, or by a portion of the electric circuit, heated by the battery to bright incandescence.

344. It is curious, that in the electrolysis of water, the minute bubbles of H. only appear at the negative pole; and those of O. at the positive; notwithstanding that if the decomposition is effected at any one point whatever, since the poles are not in contact, there must necessarily be a movement of the free particles, of one or of both elements from that point, to one, or to both poles.

It is perfectly established, however, that in all cases of electrolysis, on all kinds of substances, there is no such thing as a free element anywhere, except in contact with a pole.

This can be accounted for by supposing that there is not merely a decomposition of a single atom of the compound, but of a whole series or row of atoms, reaching across from one pole to the other.

345. Suppose the electrolyte to be water; the arrangement of the letters H. and O. in the first line below, representing a series of ten atoms of water, forming a line between the two poles + and — would indicate their condition before the electrolysis begins; and before any liberation of either element; while the arrangement in the second line indicates the result of the decomposition of apparently one atom of water; an equivalent of H. being free at the negative pole —, and also one of O. at the positive +; nine undecomposed atoms being left.

1	2	3	4	5	6	7	8	9	10		
+	H.	O.	H.	O.	H.	O.	H.	O.	H.	O.	—
	1	2	3	4	5	6	7	8	9		
+	O.	H.	O.	H.	O.	H.	O.	H.	O.	H.	—

By this it is meant to represent that there has been a decomposition of ten atoms of water, in order to leave a single final decomposition of one atom; and to bring an atom of O. to the positive pole and one of H. to the negative; the other nine atoms of each, having recombined.

In this way, then, the ten atoms of H. have each made, simultaneously, a half step toward the negative pole, and those of O. also, a half step in the opposite direction; so that, while at each end of the line, a single atom is free, the other eighteen have merely changed partners.

This supposition is well sustained by facts; one of which is, that the greater

Quantity of electricity required to decompose a grain of water? Describe the decomposition of water, 423? Collection of the gases, 424?

[344. What is curious in the electrolysis of water? Why? What is perfectly established in reference to free elements in the electrolyte? How accounted for?

345. Can you give the explanation? Fact sustaining the supposition in the explanation?]

the distance of the poles apart, the more difficult is the decomposition, since so many more atoms have to be decomposed for the same result.

III. 425. Water colored blue, with a drop or two of a solution of Indigo in Sulphuric acid, or with any vegetable coloring matter, and containing some Chlorid of Sodium, NaCl , is almost instantly bleached by the liberation of Cl , on the immersion of the battery poles. If the poles are not moved, it can be seen that the decolorization begins at the positive pole; proving that the Cl is there liberated. The Sodium, the other element of the NaCl , does not appear, since it combines with the O . of the water, to form Soda, NaO ; while H is liberated instead of it, at the negative pole. In a little time, and by moving the poles around briskly, the H and Cl will form a mixture of froth on the surface of the liquid, and may be detonated by a lighted match.

346. The poles of the battery are generally terminated with Platinum, so far as they are to be immersed in the substances acted upon. Were Copper poles, or poles of any of the more oxydable metals to be employed, on immersion, the positive pole would in many cases be corroded; and the electro-negative substance eliminated would disappear, on account of its combination with the metal.

III. 426. A mixture of Starch water and solution of Iodid of Potassium, KI , turns purple, by the liberation of the I and its action on the Starch (Art. 10). The color appears at the Positive pole, showing the I to be there liberated. The Potassium K , like the Na , is oxydized as fast as liberated; H appearing at the negative pole instead of it.

III. 427. A mixed solution, of Ferrocyanid of Potassium and Nitrate of Potassa, which is nearly colorless, acquires a deep color on being subjected to the action of the battery.

This is the basis of the electro-chemical Telegraph, or "Bain's Telegraph."

III. 428. A solution of Acetate of Lead is decomposed, and brilliant scales of metallic Lead appear at the negative pole.

III. 429. A piece of metal or plaster cast covered with graphite (plumbago), attached to the negative pole, and both poles immersed in a solution containing Copper, that metal is gradually deposited uniformly upon the surface of the metal or cast, and may be afterward separated, having exactly the impression of every variation in the surface upon which it was deposited.

This is the basis of the *electrotype* process by which an engraving may be copied and the copies multiplied to any extent; or common printing type may be faced with Copper.

III. 430. A similar arrangement as in III. 428; but with the body to be covered, immersed in a solution of Cyanid of Silver, there is a deposit of Ag upon its surface.

This illustrates the process of *electroplating*, which consists in covering bodies by electrolysis, with metallic silver.

III. 431. The same arrangement with solution of Cyanid of Gold.

Chlorine from what eliminated, how, and how proved, 425? Sodium, 425?

346. Battery poles why terminated with Pt ? Describe the decomposition of Iodid of Potassium, 426? I appears where? Ferrocyanid of Potassium, 427? Electro-Chemical Telegraph? Acetate of Lead, 428? Solution of Cu , 429? *Electrotyping*? Solution of Silver, 430? *Electroplating*? Solution of Gold, 431?

This illustrates *electro-gilding*, or the process of covering with Gold by electrolysis.

Ill. 432. A solution of Sulphate of Soda, colored with red cabbage water, being placed in the apparatus (fig. 58), the liquid in the tube, around the positive pole, is turned red by the liberated Sulphuric acid, and that in the other, green, by the alkaline action of the Soda.

347. These operations give some indication of the decomposing action of the Galvanic battery. By proper arrangements a great variety of compounds may be decomposed.

Galvanic electricity has been a valuable agent in scientific research; and has very greatly aided the progress of chemical science. By its assistance Davy made his renowned discoveries of the existence of Potassium, Sodium, etc., in the alkalis.

The process for depositing metals by means of the battery, from solution, in electrotyping, and electroplating, and gilding, belong to the art of *Electro-metallurgy*, or working in metals by electricity.

348. *Combination*, as produced by electricity, seems to be mainly a secondary result. When it is produced by the battery, it is connected with decomposition as in the oxydation of metals connected with the positive pole.

The electricity developed by the glass electric machine in consequence of friction, or that discharged from clouds in thunder storms, or from the atmosphere, is capable of causing direct chemical combination of mingled elements, as in case of the formation of Nitric acid, Ammonia, and Water, already referred to (Arts. 218, 248, and 314).

349. In connection with the appearance of the Aurora Borealis, there has been repeatedly noticed a continued action of electricity, over the circuit of the Telegraph wires, capable sometimes of producing chemical and heating effects equal to those of one hundred and fifty cups of a Grove battery.

350. Those substances in electrolysis which are attracted to the *negative pole*, are termed *electro-positive* substances, while those that are attracted to the *positive pole*, are termed *electro-negative*.

Electro-gilding? Effect of Galvanic electricity on Sulphate of Soda, 432?

347. Value of Galvanic electricity to science? What discoveries did Davy make by means of it? What is Electro-metallurgy? Modifications of Electro-metallurgy?

348. Combination as produced by electricity? Machine electricity or that discharged in thunder storms is capable of producing what? Examples?

349. Action of the electricity of the Aurora Borealis and the Telegraph wires?

350. What are those substances that are attracted to the negative pole termed? Those to the positive pole?

This is in accordance with the electric principle, *that bodies in different electric conditions, attract each other*. If a pole is positive, the substance that is attracted to it must be therefore considered negative.

It has been seen in operations, 423 to 432, that O, Cl, I, and Sulphuric acid, are attracted to the positive pole of the battery. They are therefore said to be electro-negative; while H, the metals, and Soda, having appeared at the negative pole, are electro-positive.

The arrangement of substances as electro-positive and electro-negative, is merely relative; for, although H. is always positive in respect to O, it is negative in respect to Potassium.

The following series of symbols represents the more common simple substances, in their electro-negative and electro-positive relations to each other: O, the most decidedly negative, being placed first. This is succeeded by those whose negative character is less and less marked, and thus the series gradually shades into positive substances; terminating with Potassium, the most decidedly positive of all.

Any substance in the series is therefore positive in respect to any other standing to the left of it, and negative to any one on its right:

— O, F, Cl, Br, I, S, N, P, Si, Au, Pt, Hg, Ag, Cu, Pb, Sn, Fe, Zn, H, C, Al, Mg, Ca, Sr, Ba, Na, K+.

Next we may refer to the

CHEMICAL RELATIONS OF LIGHT.

351. That chemical action is a *source* of Light, is seen in the burning of all fires, as well as in the more moderate illumination, resulting from the slow consumption of Phosphorus by exposure to air, and in the decay of animal and vegetable matters. It is well known that putrefying fish and rotting wood, under favorable circumstances, yield a faint glow in the night.

The cause of the superior brilliancy of certain flames, such as that of illuminating gas, was referred to in Art. 81.

The more rapid the chemical combination is in fires, and as a

Electric principle? What has been seen in operations 423 to 432 inclusive? The arrangement of electro-positive and electro-negative substances is what? H. in respect to O? In respect to Potassium? What does the series of symbols represent? The most decidedly negative substance? The most decidedly positive? Electric relation, in the series, of a substance standing to the right of another? To the left? What is next referred to?

351. Chemical action a source of light? Explanation of the cause of the brilliancy of certain flames? From what does intense light result?

consequent the higher the temperature is, the more intense is the light. This is always true in the combustion of solids that yield no flame. In common illuminating flames, if the arrangement is such as to burn the Carbon simultaneously with the H, it is impossible to increase the light by a more rapid burning.

352. *The chemical effects of Light*, in producing decompositions, or in rendering substances active, have been referred to in connection with the Daguerreotype, Arts. 12, 16, and 146; the allotropism of Chlorine, Art. 21; the decomposition of Nitric acid, Art. 219; and the evolution of O. from Carbonic acid, by the aid of the organism of the green leaf, Art. 39.

The most active rays of those which emanate from the sun, in producing chemical decomposition, as of the compounds of Silver with I, Br, and Cl, in photography, are the violet and even the more refrangible rays of the solar spectrum; but the yellow has the greatest effect on vegetation.

THE CHEMICAL RELATIONS OF HEAT.

1st.—ITS CHEMICAL SOURCES, ETC.

353. It is considered to be established, that there is an invariable development of heat in all chemical combination. And this is now conceded to be an ultimate fact, for which no complete and consistent explanation can be offered.

It is also held, as before intimated, that the quantity of heat developed in combustion, respiration, or in chemical combination of any kind, is in the same ratio as the number of equivalents that combine: so that, if the amount of heat developed in the combination of a substance with an equivalent of O. is taken as a standard, the combination of two equivalents of O. must produce twice as much heat; or, if any substance combines with two equivalents of Cl, twice as much heat is produced as if that or any other substance combines with one equivalent of O.

354. The nature of *fire* and *flame* and the chemical explanation of these phenomena has been made (Arts. 4, 30 to 38, 81 to 86), so that now we need only to notice certain relations and effects of heat.

352. Give examples of the chemical effects of Light in producing decompositions? The violet and more refrangible rays of the solar spectrum? Of the yellow? The next subject to be attended to?

353. Chemical action, and heat? Ratio of the quantity developed in combustion, respiration, or chemical combination? Combination of an equivalent of O, and of two equivalents of O. or Cl?

354. Nature of fire and flame?

355. It is explained in treatises on the Physical subject of Heat, that variable amounts of heat will be required to warm different substances to the same degree.

Suppose it is desired to raise the temperature of a pound of water from 45° to 60° . Let the quantity of heat necessary to produce this effect be represented, arbitrarily, by the number 1000. Then, how much heat comparatively will be required to raise a pound of Zn. from 45° to 60° ? Experiment has shown that the quantity required for this purpose will, on the same scale as before, be but 95.

SPECIFIC HEAT is the comparative amount of heat required to equally raise the temperature of equal weights of different substances. Water is the standard in this respect; and its specific heat being represented by 1000, that of Zinc is 95.

356. This subject is of great practical, as well as of theoretical importance, and has received considerable attention from scientific men.

Their investigations have been conducted, and their results obtained, in various ways. One of the processes used, is known as the "method of mixtures," and may be illustrated as follows:—

III. 433. Equal weights say of water and of Mercury, but at different temperatures; the water for example at 200° , and the Hg. at 50° , are thoroughly stirred together, a thermometer being inserted into the vessel, to indicate the instant when the temperature of the Hg. ceases to rise.

If the operation is performed on a sufficient scale, and with perfect accuracy, the result should be 195.2, for the temperature of the Hg, when it ceases rising.*

The water and the Hg. being then both of the same temperature, the water will have lost 4.8° , and the Hg. have gained 145.2° . Then, since the heat which has warmed the Hg. has come from the water, and must be equal to what would warm the water 4.8° , it can be concluded, that the same amount of heat which would raise the temperature of water 4.8° , would raise that of Hg. 145.2° ; and that their specific heats are in the inverse ratio of 4.8° to 145.2° , which is, very nearly, 1,000 for water to 33 for Hg.

The specific heat of most common substances has been determined. The results exhibit an interesting relation between

* It will be found very difficult, without great pains, to reach anything like the result here given; but, managed in the most off-hand manner, the experiment can not fail to show a very striking disparity between the gain in temperature of the Hg, and the loss in that of the HO.

[355. The comparative amounts of heat necessary to raise the temperatures of a pound of water, and one of Zinc from 45° to 60° ?] What is Specific heat? The standard in respect to Specific heat? If the Sp. heat of water is 1,000, how much will Zinc be?

[356. Importance of a knowledge of Specific heat? One of the processes for determining Specific heat? How may this process be illustrated, 433? If the experiment is conducted with perfect accuracy what should the result be?

specific heat and combining ratio. For, in many cases, it is found that the same amount of heat is required to equally raise the temperature, of equivalent weights, of different substances, as, for example, that of 28 pounds of Iron, and of 58 pounds of Tin. The progress of investigation may establish the principle that the specific heat of the atoms of all substances is either the same, or is in some simple ratio.

2d.—CHEMICAL EFFECTS OF HEAT.

357. These consist in the production of *decomposition* and *combination*. And while Light and Electricity are important agents, in modifying chemical attraction, and producing changes in the constitution of bodies, the influences of heat if not more nearly universal, are generally much more available.

Electricity is most frequently employed in the character of an opposing force to Affinity; as in the production of direct decomposition; but, while Light and Heat are both occasionally employed in the same way, they more generally appear, not as independent agents, but as modifying influences to aid, direct, or control the action of Chemical attraction.

358. The time was, when Electricity, Light, and Heat, were considered to be *material substances, or fluids*, but of such extreme tenuity, that their weight, if they were supposed to possess any, was wholly inappreciable; hence they were termed the Imponderable Bodies, or Agents. This view has been gradually losing ground, until the present time.

Now, theorists seems generally to consider it as altogether more probable, that the phenomena heretofore ascribed to the action of material fluids, under the names just given, are more likely the result of certain motions or conditions, among the atoms of ordinary matter.

This view would associate Attraction, Electricity, Light, and Heat together more intimately than the other, and accordingly, the Chemical relations of these "*four agents*," or modes of action, have been considered in connection, in this part of our course.

For, having attended somewhat to the peculiarities and intimate constitution of different material substances, we are here better prepared to understand any relations which these substances may have, to anything unusual, among their properties or conditions.

And, certainly, those extremities, in temperature and luminosity, which are recognised as constituting Heat and Light, and that peculiar excitement, or state, termed Electricity, are not the commonest, if they are the normal condition of matter. The subject, however, here opens into such extensive

In what ratio are the Specific heats of Mercury and water?

357. The Chemical effects of heat? Action of Light, Electricity, and Heat, in causing changes in the constitution of bodies? Electricity most frequently employed in what way? How do light and heat most generally appear?

[358. What were Electricity, Light, and Heat, formerly considered to be? What were they termed on this account? What is the present theory? What agents would this view associate?]

limits, that room can not be found for further philosophizing; and we must confine ourselves to the narrow business which is more particularly the present object in view.

359. What is called *heat*, then, is capable in numerous instances, of producing the opposite effects of *combination* and *decomposition*.

III. 434. A very small strong glass cup, filled with a mixture of O. and H. On the application of flame, there is an explosion in consequence of the combination of the mixed gases, and the formation of water.

III. 435. The same cup being perfectly cold and dry, a few crystals of Chlorate of Potassa are introduced into it, and a little Sulphuric acid. A bright yellow gas, Hypochloric acid, ClO_2 , a compound of Cl. and O, soon appears. This, on the application of flame, explodes violently, in consequence of its decomposition into its elements.

Here, then, heat, applied in the same way produces precisely opposite effects, a *combination* of previously *mixed* elements in the former instance; a *decomposition* of previously *combined* elements in the latter. And the substances acted upon, are in both cases, in the same form, namely, that of gas.

360. But, as before noticed, the agency of Heat is more frequently a modifying agency, exerted at particular temperatures, where, often several affinities are brought into play, to influence them in particular directions.

Examples of this sort have appeared, in the operations already employed for other objects. Thus, by a moderately elevated temperature, Chlorate of Potassa, Art. 28, containing three elements, Cl, O, and K, has been made to give up its affinity for O, so that that element was eliminated, while the attraction between the Cl. and the K, has been undisturbed, if not strengthened, and these have remained in combination.

Again, by a moderate heat, Nitrate of Ammonia, Art. 158, was made to yield a compound gas, the Monoxyd of Nitrogen, which would afterward support burning, by means of its O; while, by a red heat, Art. 258, on a live coal, the same substance was made to yield O. simultaneously with its own decomposition, and thus to cause a violent burning of the coal.

It is by the powerful heat in the constant blast of a tall furnace, that an ore of Iron is made to yield up its O. to the superior affinity which the Carbon mingled with it, can exert, at this temperature.

At a lower temperature, even in the presence of the coal, this

359. Opposite effects of heat? Combination by heat, 434? Decomposition by heat, 435?

360. Chlorate of Potassa? Nitrate of Ammonia? Iron ore?

result could not be attained; nor could it, at any known temperature, however high, if the coal were absent, and the ore alone; while, without the ore, the coal thus heated, would have its attraction for O. satisfied wholly from the atmosphere, instead of taking a portion of it from the ore.

However, these matters are only suited to the more advanced student, and, therefore, passing from their consideration, the third part of the course, treating of Organic Chemistry, may now be entered upon.

Next subject entered upon?

PART III.

THE

CHEMISTRY OF PLANTS AND ANIMALS,

AND

THEIR LIVING PRODUCTS;

OF THE

RESULTS OF THEIR NATURAL DECAY,

AND OF THEIR

ARTIFICIAL TRANSFORMATIONS.

361. This portion of the subject is denominated ORGANIC CHEMISTRY; since it is the Chemistry of bodies supplied with *organs*, by some of which they transform the matter that nourishes them into a part of themselves; as well as *other organs*, by which peculiar products are formed, that are destined for other uses than those which the necessity of the individual may require.

All substances that, as compound elements, constitute a portion of animal and vegetable tissues, or of their natural products, as well as those substances which the Chemist can form, only from an animal or vegetable production, are termed indiscriminately, *organic substances*.

The substances in this series are remarkable in respect to their composition and the means of their formation.

1st.—COMPOSITION OF ORGANIC SUBSTANCES.

362. *Organic substances consist chiefly of the four elements; Oxygen, Carbon, Hydrogen, and Nitrogen.*

While some of the other simple elements, enter to a moderate extent into their composition, not more than fifteen or

What departments of the subject are mentioned under Part III?

[361. Why *Organic Chemistry*?] Organic substances? These are remarkable for what?

362. The four chief elements of organic bodies? How many of the simple substances enter into their composition?

twenty at the outside, of the more than sixty simples known, are recognised as being regularly present in organic bodies.

363. Organic substances are distinguished for the large number of equivalents which enter into their composition; for, while some, such as Cyanogen and Olefiant gas, are quite simple in their constitution, containing three or four equivalents only, and thus approach inorganic substances in composition; by far the larger share, and especially those that are formed by the aid of vital action, contain from a dozen, to a hundred or more equivalents.

364. Since O, C, H, and N, form so large a share of organic bodies, they have received the distinguishing title of the *organic elements*.

They have, likewise, by way of distinguishing them from certain other elements in plants and animals, received the title of the *volatile organic elements*.

Generally, when a solid animal or vegetable substance is burned in the fire, some ashes remain. The substances left in these ashes, having withstood the heat and remained fixed, are called the *fixed organic elements*.

In the burning, all but the ash, which is never but a small percentage of the whole, disappears in an invisible form, as gas or vapor, and passes, for the most part, into the atmosphere; from which, indeed, it was originally, chiefly derived.

365. In this operation of burning such bodies, the volatile elements C, H, N, and O, or that portion of them really constituting an animal or vegetable tissue, or product, go into the air mostly, in the shape of *Carbonic acid* CO_2 , *water* HO , and *Ammonia* NH_3 ; substances previously noticed and whose properties the student now well understands.

In the ashes, the fixed elements constitute such well known substances, as Chlorids, Fluorids, Iodids, Bromids, Sulphates, Nitrates, Phosphates, Carbonates, Silicates, Hydrates, and perhaps some Oxyds and Sulphurets, containing the simple elements, I, Br, Cl, F, O, S, N, P, C, Si, H, K, Na, Ca, Mg, and Fe, and sometimes Mn, Cu, and As, say nineteen in all; and some of which can not be said to be regularly present.

363. Equivalents of Organic Substances? Examples and why of those that approach Inorganic substances?

364. What titles have O, C, H, and N, received and why? What remains when an animal or vegetable solid substance is burned? The substances left in the ashes are called what? Percentage of the ash? Besides the ash what becomes of the remainder? Whence was it derived?

365. In this burning what are the volatile elements converted into? The fixed elements constitute what in the ash? Mention the simple elements of Organic substances, and tell how many in all?

These salts, Oxyds and Sulphurets, form no part of characteristic organic substances, and will not be noticed in the description of the series.

Having considered the simple elements of organic bodies, we may proceed to notice the manner in which they are combined, to form the characteristic substances of the series ; but first we may glance at the

2d.—MEANS OF FORMATION OF ORGANIC SUBSTANCES.

366. These substances all originate with the action of the forces which are peculiar to living tissues ; being the products, or the derivatives of the products of Chemical affinities instituted, modified, or controlled by vital influences.

There are many substances artificially produced, by pure chemical means, belonging to the Organic series, but they all, without exception, perhaps, are manufactured from something that nature has produced, in or from organized bodies.

They can not be formed from the direct or indirect combination of their simple elements : indeed, should Chemists be able to form one of this series of substances, by the combination of its ultimate elements, that would be a sufficient reason to eject it from the series ; since it is desirable to have some definite and definable limit to Organic Chemistry.

The Organic Substances first in order are the

NATURAL COMPOUNDS,

PRODUCED BY LIVING PLANTS AND ANIMALS.

These may be divided into first, *vegetable*, and, second, *animal* components and products.

1st.—VEGETABLE COMPONENTS AND PRODUCTS.

367. These constitute the following groups : 1st, *Neutral ternary substances* ; 2d, *Neutral quaternary substances* ; 3d, *Alkaloids, Peculiar Principles, and Natural Coloring Matters* ; 4th, *Oils, Fats, and Resins* ; and, 5th, *Acids and Salts*.

Notice of salts, Oxyds and Sulphurets, and why ? What is next glanced at ?

366. Organic substances originate with what ? From what are artificially prepared organic substances, manufactured ? Reason for ejecting a substance, formed by the combination of its ultimate elements, from the organic series ? What class of organic substances is first in order ? What two divisions of the class of Natural Compounds produced by Plants and Animals ? Which division is first noticed ?

367. The five groups belonging to the division of Vegetable Components and Products ?

GROUP I.—NEUTRAL TERNARY SUBSTANCES.

368. These substances are called *neutral*, since they have no active properties; that is, they are not acid, nor alkaline; they are not intensely *bitter*; and do not exert any energetic effect in stimulating, deranging, or impeding animal functions, or in diverting them from their usual course.

They are *ternary*, for they contain only the three elements C, O, and H; and the O. and H. are always in the same ratio as in water. Cellulose, Starch, the Sugars, and Gum, are the chief members of this group. The first is

CELLULOSE, $C_{24}H_{20}O_{20}$. Eq. 324.

369. *Cellulose* is so named, since it is the chemical substance that constitutes the proper cell-walls and vegetable tissues. It is seen nearly pure in clean cotton, and well-worn linen.

Compacted, slightly modified, and hardened by the deposit of earthy and other matters, it becomes common wood.

Cellulose is insoluble in water, alcohol, and dilute acids and alkalis.

STARCH, $C_{24}H_{20}O_{20}$. Eq. 324.

370. This substance is abundant in the seeds of many plants; as in wheat, and all other kinds of corn, in rice, &c. It is often present in different parts of plants, and especially in subterranean stems, as in common potatoes. *Arrow-root*, *sago*, and *tapioca*, are merely starch.

Starch is composed mechanically of somewhat globose microscopic grains, which, in different plants, are of different shapes. It is insoluble in cold water, but in hot, the solid grains are changed so as to become soluble; and when the water is in small quantity, a pasty, semi-liquid mass is formed for laundry purposes.

In dissolving, the Starch seems to have undergone a chemical change, since it does not react with I, as when diffused in cold water.

Ill. 436. The action of aqueous solution of I, first on Starch diffused in cold water, and afterward on another portion in hot.

Which is the first group of Vegetable Components and Products?

368. Why are these neutral? Why ternary? In what ratio are the O. and H. always? The chief members of the group of Ternary Vegetable Neutrals? Symb. and equiv. of Cellulose?

369. Why is Cellulose so called? Where seen nearly pure? What is wood? Solubility of Cellulose? Symb. and equiv. of Starch?

370. Where does Starch abound? What are *arrow-root*, *sago*, and *tapioca*? Mechanical composition of Starch, and shape of the grains? Solubility? Effect of dissolving it in hot water, and reaction with I? Ill. 436. Starch and I?

371. *Starch* is a valuable element of food ; for, although not *nutritious*, in the correct sense, being incapable of contributing to the formation of flesh, it supplies the animal system with a portion of the Carbon and Hydrogen, which are consumed in respiration. It may therefore prevent that decomposition of flesh, which, in the absence of ternary substances in the system, would be necessary in order to supply C. and H, as aliment for respiration.

CANE SUGAR, $C_{24}H_{42}O_{21}$. Eq. 342.

372. This is the Sugar of the juices of plants, such as of Sugar cane (*Saccharum officinarum*), of beet (*Beta vulgaris*), and of several species of maple, *Acer saccharinum*, *Acer nigrum*, &c. In its crude state, it is termed *Muscovado Sugar*.

Dissolved and clarified by albuminous matters, such as blood, &c., bleached by animal charcoal, evaporated, and partially dried, it is the ordinary *white sugar* ; more thoroughly dried it is *loaf*, *lump*, *powdered*, or *crushed* sugar. The sirup, drained from it in these operations, containing sugar so altered as not to be crystalizable, is the variable liquid known as *molasses*, or, simply, *sirup*.

373. To prevent a change in constitution, the result of a too elevated temperature in the evaporation of the water, from its solution, the process is conducted at the *refineries*, in *vacuum pans*, or shallow closed iron vessels, from which air and vapor are exhausted by pumping. Thus, the evaporation proceeds at so moderate a temperature, as to prevent the decomposition of the sugar, and the product of crystalized sugar is increased.

374. Cane Sugar is soluble in $\frac{1}{3}$ of its weight of cold water. From concentrated solutions, it crystalizes in transparent crystals, which are a modification of the *oblique rhombic prism*, and therefore belong to the *Monoclinic* system, Art. 326.

The crystals constitute *rock candy*. By heat they lose four equivalents of water.

Ill. 437. Specimens of crystalized Cane Sugar.

371. Is Starch nutritious ? Why not ? What use does it serve as food ?
Symb. and equiv. of Cane Sugar ?

372. Where is Cane Sugar found ? Crude Sugar ? How converted to white Sugar, and loaf, and lump Sugar ? What is molasses, or sirup ?

373. Why are *vacuum pans* employed in the evaporation of the water of sugar sirup ? The pans how kept free from air and vapor ? Effect on the quantity of the product ?

374. Solubility of Cane Sugar ? Crystalization, shape, and system of its crystals ? Rock candy ? Effect of heat ? Specimens. 437 ?

The Sugars serve the same purpose as Starch in the animal economy: that is, they are *innutritious*, being incapable of forming *flesh*; but they may be converted to fat, and are important means of supplying aliment for respiration.

GLUCOSE, or GRAPE SUGAR, $C_6H_{12}O_6$. Eq. 360.

375. This is the sugar of honey, and of fruits of different kinds, giving them their sweetness. Its taste, however, is not so intensely sweet as that of Cane Sugar, probably owing, in part, to its less free solubility.

It requires $1\frac{1}{2}$ times its weight of cold water to dissolve it, and is not readily crystalizable.

The solid sugar contains, beside the equivalents given above, 4 equivalents of water which are expelled by heat. It is not, of itself, an article in extensive use, but has, in some cases, been employed to adulterate Cane Sugar.

376. Grape Sugar is easily distinguished from Cane Sugar, by the action of Solution of Sulphate of Copper, Potassa, and heat, which quickly cause a yellowish or reddish brown precipitate where grape Sugar is present, even in small quantity, in a mixture of the two Sugars.

III. 438. Solutions of Cane Sugar and of honey, in separate test tubes, to each of which solution of Sulphate of Copper and of Potassa are added, and the tubes held in the flame of the spirit lamp. That containing honey soon turns brown, but the other is for a long time unaffected.

Grape Sugar is interesting in consequence of its direct relation to alcoholic fermentation. Milk Sugar will be noticed in the class of Animal Components and Products.

GUM, $C_{10}H_{16}O_5$. Eq. 324.

377. This substance constitutes the purest *Gum Arabic*, and is present in that of the cherry tree, in Linseed, fruits, &c. It dissolves in water, and the strong pasty, adhesive solution is called mucilage. Gum is the chief constituent in vegetable mucilaginous substances, jellies, &c., as currant jelly.

Use of Sugars in food? Symb. and equiv. of Glucose? Other name?

375. Where is Glucose found? Why not so sweet as Cane Sugar? Quantity of water to dissolve Glucose? Crystalizability? Water in the solid Grape Sugar? Use?

376. By what means are Cane and Grape Sugar distinguished? Describe the operation, 438? In what relation is Grape Sugar interesting? Where is Milk Sugar noticed? Formula and equiv. of Gum?

377. Where is Gum found? Solubility? Mucilage? Vegetable mucilaginous substances and jellies?

As an article of food it is of the same character as Starch, and the Sugars.

III. 439. Specimens of gum.

REVIEW.

378. A remarkable similarity prevails in the *composition* of the members of this group. They not merely consist of the same elements and have the O. and H. which they contain in the same ratio: but Cellulose, Gum, and Starch, have the same composition. The Sugars vary, among each other, and from Cellulose, Starch, and Gum, only in having a few more or less equivalents, of the elements of Water.

This similarity in composition favors those transformations of one into another, which are so common in plants. The mucilaginous matter, in the juices of plants, is organized into Cellulose for the cells and tissues: it is given a sort of organized arrangement, and deposited in the tissue, in minute grains, as Starch: It is made to take a trifling difference in composition and is converted into Cane Sugar, which dissolved, circulates in the juices of the stem and branches: or modified somewhat differently, it increases in quantity in fruits as they ripen, and is converted into Grape Sugar.

379. The Starch which is accumulated in seeds, serves, as they germinate, to nourish the young plant; the Cellulose of which, constituting its cells, is derived from the Starch of the sprouted seed.

So also, the accumulated Starch of the potato tuber, serves to nourish the sprouting bud, and this loss causes the potato to become shrivelled.

Notwithstanding the *similarity*, in composition of the members of this group, and the *identity*, even, in some, they are evidently unlike in properties.

Cellulose is insoluble in water, whether cold or hot; Starch is soluble in hot water but not in cold; the Sugars and Gum dissolve in cold water. The sugars are crystalizable; Gum, Cellulose, and Starch, can not be crystalized. Cellulose and

Gum as an article of food? Specimen, 439?

378. Members of this group how similar? Elements? Ratio of O. to H? Composition of Cellulose, Gum, and Starch? How do the Sugars vary from each other and from the other members of the group? This similarity in composition favors what? Describe the modifications which the Gum, or mucilaginous substance of plants undergoes?

379. Transformations of Starch in seeds and tubers? The Ternary Vegetable Neutrals are *similar*, *identical*, and *unlike* in what? Solubility, crystalizability and organization of the members of this group?

Starch have an arrangement of their particles that is the result of the action of forces exerted by the living plant; Gum and the Sugars are destitute of any such organization.

380. Hence, a principle, before unreflected to, is developed in connection with this group: namely, that the same elements may be combined in the same proportions, and yet form different substances. This principle is termed *Isomerism*, and Starch, Gum, and Cellulose, are examples of *isomeric* bodies.

There seems to be, with these three substances, some reason for the difference in properties, in consequence of the difference in structure, but examples will hereafter occur, to account for which, no such reason is apparent.

Other transformations of the members of this group, and occurring without the modifying influence of the living plant will be hereafter noticed. Next in order we have

GR. II.—NEUTRAL QUATERNARIES; (*of the Formula, $C_{24}H_{17}N_3O_8$.*)

381. These substances are termed *quaternary* since they contain the four elements, Carbon, Hydrogen, Nitrogen, and Oxygen. They are *neutral* in the same sense as the members of the preceding group.

In composition they may be regarded as identical with each other; and, in a modified form, they are animal, as well as vegetable elements.

382. In the vegetable form they are known as GLUTIN or *vegetable fibrin*, VEGETABLE ALBUMIN, and LEGUMIN, or *vegetable casein*.

GLUTIN abounds in the different kinds of *grain* and other seeds of grass-like plants.

In these it is associated with Starch, some vegetable Albumin, Cellulose, Sugar, &c.

III. 440. Cover a jar with a single thickness of fine thin muslin as a strainer, and place some wheat flour upon this. Then moisten the flour into a paste, and continue to wash the paste with water, until the Starch has passed through the cloth into the vessel below.

380. What new principle do Starch, Gum, and Cellulose develop? Name of this principle? Mention isomeric bodies? Reason for a difference in properties of these substances having the same constitution? Other examples? What transformations of the Ternary Neutrals will be hereafter noticed? What group comes next and how is it designated? Meaning of its formula?

381. Why quaternary? Neutral in what sense? Relations of the Quaternary Neutrals to each other in composition? Of what beside plants are they elements?

382. Names of the Vegetable Quaternary Neutrals? Where is Glutin found? With what is it associated in seeds? Separation of Glutin, 440?

By washing wheat flour in this way there remains upon the cloth, a grayish, tough, adhesive, insoluble substance which is Glutin.

383. The water used in washing the flour soon becomes clear as the Starch settles away. This water contains the vegetable Albumin, a substance having the same properties as white of eggs. By using the same water repeatedly, an increased quantity may be dissolved. The juices of plants also contain the same substance.

When this Albuminous solution is heated, it loses its transparency, on account of the coagulation of the Albumin into a solid substance, an effect also produced by several acids, as the Sulphuric, and by earths and metallic salts.

Ill. 441. Coagulation by heat of the Albumin in flour water.

Ill. 442. The Albumin is also coagulated by acid.

Ill. 443. Solution of Chlorid of Mercury coagulates the Albumin of flour water.

384. *Leguminous*, or pod-bearing plants, like the pea and bean, contain in their seed, the LEGUMIN, or *vegetable Casein*. The *Casein* of milk, to be hereafter noticed, has the same properties.

Ill. 444. Bruised beans or peas are left standing in water. The Leguminous solution is unaffected by boiling, but an acid causes precipitation.

385. Glutin, Legumin, and vegetable Casein, disregarding their impurities, consist essentially, as before noticed, of C, H, N, and O, but they generally contain a very little Sulphur and Phosphorus; the former of which may possibly replace O, and the latter N.

Freed from impurities, and their variable quantities of S, and P, being considered as O, and N, respectively; they all have the formula, $C_{24}H_{17}N_3O_8$, and though, of the same composition, differ, as has been seen, in properties; Glutin being wholly insoluble, while the other two, at least before coagulation, readily

383. Starch how separated? What remains in the clear water with which flour has been washed, etc.? Albumin has the same properties as what substance? Larger quantity how dissolved in water? Where else is Albumin found? Effect of heat on the Albuminous solution? Albumin how coagulated in 441? 442? 443?

384. What are pod-bearing plants like the pea and bean called? Where is Legumin found? What other name for Legumin? What animal substance has the same properties? Operation on solution of Legumin, 444?

385. Elements of Glutin, Legumin, and vegetable Casein? Possible condition of the S. and P. which they contain? Are the quantities of S. and P. constant? What formula have the quaternary neutrals, and with what qualification? Are their properties alike?

dissolve. And these latter also differ, since Albumin is coagulable by heat, and Legumin is not.

386. Like the members of the previous group, they are, by natural, and to some extent, by artificial means, converted into each other.

Albumin, which, as before mentioned, is present in the juices of plants, plays, in their growth, an absolutely indispensable part. Plants increase in size by a process of cell-formation; and it is found that Albumin is invariably present in the active lining of cell walls. Being thus indispensable to vegetable formation, and organization, it is termed *protoplasm*, that is, the *first-forming material*.

387. Albumin does not remain, as a proper constituent of the real cell-walls; for, as the activity of the cells becomes no longer necessary, in those parts of the plant which are completely formed, and are then to remain as a quiescent part of the vegetable structure, such as the inner portion of the stems of herbs and the trunks of trees; the active Albuminous lining disappears, being absorbed and transported to the growing portions of the plant.

Thus a very small quantity of *protoplasm* may serve the purposes of the growing forces, being active in the formation of one set of cells, and then, leaving them, and passing on to assist in the building of others.

388. The Albumin is itself produced in the vegetable organization; its N. having been derived from the Ammonia, NH_3 , and its C, H, and O, from the water, HO, Carbonic acid, CO_2 , and Ammonia, which the plant has absorbed. Ammonia, Carbonic acid, and water,—these three substances, constitute the material from which the Organic elements are derived. They are absorbed by plants in two different ways; the Ammonia and Carbonic acid come *in* to the plant in the liquid form, dissolved in water, and absorbed through the roots from the soil; and also, all these are taken *in*, in the form of gas and vapor, by the leaves, directly from the atmosphere.

How do they differ in properties?

386. Mutual convertibility of Quarternary neutrals? Albumin, and the growth of plants? How do plants grow? Where is Albumin invariably present? Why termed *protoplasm*? Meaning of the term?

387. Albumin as a permanent constituent of the cell walls? From what part of the plant is it withdrawn? To what part transported? Quantity of *protoplasm* may how be small?

388. Albumin where produced? Source of its N? Of its C, H, and O? Symbols of the substances that supply C, H, N, and O, to from Albumin? What three substances are the material for the derivation of the organic elements? How are NH_3 , CO_2 , and HO, absorbed into plants? Two ways?

389. The vegetable Albumin, then, seems to be the source from which the other Quaternary Neutrals, are derived. In Leguminous plants, it is modified to form the Legumin of their seeds. And in seeds generally and especially in grain, having received a low organization, and become converted into Glutin it is stored, in an insoluble form, so as not to be lost, against the time when it shall be again required.

With many plants, the formation of seed is the last office of their existence,—this process accomplished, their juices then disappear,—*they* wither and die,—and when their stalks are chemically examined scarcely an *Albuminous* trace can be found; the whole having been transferred and stored up, in the seed.

390. But the new occasion for the Albuminous matter, arises, when the seed is to originate a new individual:—a young plant, —which, as it begins to spring forth, having no organs of its own, by which it can act, like the mature plant, upon the earth and the air, and take its nourishment from them—is dependent upon the stored Glutin, for the material of its *protoplasm*, and the first formation of its new cells and their active linings; while the real walls are formed from the starch, which has been likewise deposited in the seed for that purpose.

391. *These quaternary substances are the most important vegetable products.* They are the ultimate sources of the nourishment of animals; for, being identical with flesh in composition, they furnish without chemical change, the material out of which muscle or flesh is organized.

Even Carnivorous animals are dependent upon these vegetable substances; for it is from these, that the flesh of their prey has been derived.

It will be seen hereafter that the process of the formation of animal tissues, and especially of that which constitutes muscular fibre or flesh, is merely an organizing process,—a process in which the tissue is constructed out of material derived from the food, and originally from the vegetable kingdom.

389. Which of the Quaternary Neutrals is the source of the others? Probable source of the Legumin of beans? Into what insoluble condition is Albumin converted in seeds, how and for what purpose? Final office of many plants? When the seed is perfected, what in many cases becomes of the plant? Is Albumin found in their dead stalks? What has become of it?

390. When does the new occasion, for the stored albuminous matter, arise? Why can not the germinating plant take its nourishment from the earth and the air, like the mature plant? Where does it get the material for its protoplasm and for its cell walls?

391. Importance of the Quaternary Neutrals and why? Their composition and that of flesh? Chemical change of the material in the organization of flesh? Carnivorous animals?

The animal has no power to change the chemical constitution, even of substances containing the requisite elements, into matter for the formation of flesh. This office is performed solely by plants.

The vegetable organization takes the mineral substances, Ammonia, Carbonic acid, and water, from the earth and the air; it changes them into new substances of a peculiar chemical composition,—into Glutin, Legumin, vegetable Albumin; or substances having the same essential composition, and then these

Fig. 59.



A Tree, as a symbol of the vegetable agencies, by which air, water, and earth become food.

products thus ready formed, become the food of animals and are employed, without change in chemical composition, in the construction of the animal fabric.

Hence these *Neutral Quaternary Compounds* constitute the connection on one side between animal and vegetable life; the connection on the other hand, in which matter passes from the animal to the vegetable kingdom remains to be exhibited.

A green tree, then, fig. 59, may symbolize to the mind the whole vegetable world, by means of many different species of which, AIR, WATER, and EARTH, are transformed from their inert, and wholly unavailable state, into those substances that shall serve as food for man.

392. Next in order, is the third Group of Vegetable Components and Products comprising Alkaloids, Peculiar Principles, and Natural Unchanged Coloring Matters.

1st.—THE VEGETABLE ALKALOIDS.

These substances are quite numerous: the most important

What ideas does a plant, as a green tree, symbolize?

392. What is comprised in the third group of Vegetable Components and Products? What substances of group 3 are first noticed?

are Morphine, Quinine, Caffëine, Theobromine, Strychnine, and Nicotine. These may be taken up in order.

393. MORPHINE, $C_{17}H_{19}NO_5$, *Eq.* 285, is an alkaloid, existing in *opium*, from which it is extracted and converted into saline preparations for medicinal use. The properties of the concrete juice of the *Papaver somniferum*, known as *opium*, depend chiefly upon the presence of this alkaloid; although there are several other similar principles present. Morphine derives its name from the Greek, *Morpheus*, the God of sleep on account of its somniferous properties.

394. QUININE, $C_{20}H_{22}N_2O_4$, *Eq.* 310, is the most valuable constituent of Peruvian bark. Like Morphine it is converted into some saline form for medicinal use. These two alkaloids are much less soluble in water than their salts, and therefore their saline forms are more readily active on the system.

395. CAFFEINE, $C_{16}H_{10}N_4O_2$, is the chief active principle of *tea* and *coffee*. It is more abundant in green tea, of which it constitutes two to five per cent. while it is less than one per cent. of coffee. Caffëine is more readily soluble in hot water than the preceding alkaloids and is much less poisonous and less strongly alkaline and basic.

THEOBROMINE, $C_{14}H_{10}N_4O_2$, is contained in the seeds of *Theobroma Cacao*, from which chocolate is manufactured. It is less active than Caffëine.

396. STRYCHNINE, $C_{41}H_{54}N_8O_6$, is one of the most powerful poisons known, a single grain being capable of causing death. It is found in the *Strychnos nux-vomica* and in other species of the same genus. It is intensely bitter, being capable of imparting a bitter taste to 600,000 parts of water.

397. NICOTINE, $C_{10}H_{14}N_2$, may be referred to, in connection with the previously named substances, though it differs from them in containing no O, and in not crystalizing.

The most important vegetable alkaloids ?

393. Symb. and equiv. of Morphine and why? Where is Morphine found? Into what is it converted and for what purpose? What is opium and on what do its properties chiefly depend? Name of Morphine and why?

394. Symb. and equiv. of Quinine and its meaning? Where found? Medicinal form? Reason why used as salts?

395. Symb. of Caffëine and why? Active principle of what? Quantity in green tea and coffee? Solubility? Poisonous, basic, and alkaline properties? Symb. of Theobromine and its meaning? Where found? Activity?

396. Symb. of Strychnine and its meaning? Poison? Where found? Bitterness?

397. Symb. of Nicotine? Differs how from the other alkaloids?

It is the active principle of the *poisonous tobacco plant*, (*Nicotiana Tabacum*, etc.) forming, sometimes, as much as six or seven per cent. of the commercial article. Nicotine is one of the most active known poisons and can not fail to be injurious to the systems of smokers and chewers.

In consequence of recent investigations it may be inferred to be generally present in the urine of smokers.

A single drop of pure Nicotine will kill a dog, and the odor of it will destroy birds. It is caustic and burning like alkalies upon the skin. The inhalation of tobacco smoke has caused death.

398. These alkaloids agree in being capable of uniting with acids to form salts; though as noticed, their basic properties are not equally strong.

This basic property, the alkaline reaction of some of them, and their capability of combining like Ammonia, to form similar series of compounds, have caused them to receive the common name of alkaloids or vegetable alkalies.

III. 445. Specimens of Alkaloids.

III. 446. Alkaline and other reactions of Morphine, etc.

This group is interesting both theoretically and practically, but other substances must now receive attention.

The next substances of the present group are

THE PECULIAR PRINCIPLES OF PLANTS.

399. This is a sub-group, embracing a very great number of substances. Almost every genus, and indeed many species of plants, contain some principle, peculiar to the species, and the cause of the characteristic effects of the plant or its preparations, on the animal system. As chemical research is continued, and the vegetable kingdom is further investigated, new substances of this character, are being discovered.

These Peculiar Vegetable Principles are mostly *ternary*; consisting of the three simples, O, C, and H, though many are of a more complex composition. They are often bitter and generally crystalizable. One or two only, of the most common, will receive attention, namely Salicin, Phloridzin, and Amygdalin.

Active principle of what? Poison? Smokers and chewers? A drop of Nicotine? Action on the skin? Inhalation of the smoke?

398. Respects in which the vegetable alkaloids agree? Why called alkaloids? Specimens, 445? Reactions, 446? Next substances of the group?

399. Great number of peculiar principles and how? Their elements? What three are noticed?

400. SALICIN, $C_{10}H_{10}O_8$, is found in different species of bitter willow.—plants of the genus *Salix*, whence its name. It is bitter, soluble, crystalizable, and is used in medicine.

PHLORIDZIN, $C_{18}H_{12}O_{10}$, is contained in the bark of the roots of the *apple*, *pear*, and *cherry tree*. It is bitter and crystalizable.

AMYGDALIN, $C_{10}H_{17}NO_{11}$, is present in the kernels of peach and cherry stones and of bitter almonds. The substance derives its name from *Amygdalus*, a generic name for plants of the peach family.

It is soluble, crystalizable, and bitter; and is said to have narcotic effects. Next in order are

401. The *Coloring Matters* which exist ready formed in living plants. The most nearly universal of these, is known as

Chlorophyll, or leaf green. This is the substance that is the cause of the green color in vegetation; and the decomposition of which, effected in autumn, by the combined influences of the atmosphere and of various principles in plants, then gives rise to all the variety of the magnificent hues of our forests.

The composition of Chlorophyll like that of most coloring matters of this sub-group, is not established; the investigation being attended with great difficulties, on account of the instability of the substances to be examined, and their small quantity in reference to the vegetable matter with which they are associated.

The whole amount of Chlorophyll in a large tree is thought not to exceed one hundred grains in weight. Being produced by the aid of light, it is not found in plants or parts of plants protected from the influence of that agent.

402. *Xanthin*, is a substance existing in the madder plant (*Rubia tinctoria*), from the decomposition of which the common coloring matter is derived.

Violets, purple dahlias, the *Iris*, and *red cabbage*, contain a coloring matter, valuable as a chemical test, since it is reddened by acids and turned green by alkalis.

The coloring matters of vegetable origin which are, however, the result of natural and artificial changes in the constitution of original vegetable principles, will be noticed farther on. The next Group of Vegetable Compounds and Products is

400. Symb., source, and name of Salicin? Properties and use? Symb., source, and properties of Phloridzin? Of Amygdalin? Name!

401. Next in order? Universal vegetable coloring matter? Chlorophyll the cause of what? Composition? Quantity? Action of light?

402. In what is Xanthin found? Color of violets, etc.? Other coloring matters where noticed?

GROUP IV.—THE VEGETABLE OILS AND FATS,

Which exist in living plants.

403. A peculiarity may be noticed in the composition of the members of this group. They are almost all *ternary* or *binary*, consisting either of C, H, and O, with a very small ratio of the latter; or they are composed of C. and H. alone.

The group of Natural Vegetable Oils and Fats may be divided into two sub-groups: Firstly, those that can not be volatilized unchanged, and which are therefore said to be *fixed*; and secondly, those that readily evaporate and are called *volatile*.

THE FIXED VEGETABLE OILS.

404. These oils are generally separable into a fluid portion termed *olein*; and a solid substance termed *margarin*, since its acid forms *pearly* salts. Special names however are sometimes given to the solid and fluid part of the natural oil. The composition of these substances is not constant, so that formulas can not be assigned to them; but they consist chiefly of Carbon, with several equivalents of H. and a very few equivalents of O.

405. The fixed oils are divided into two subdivisions:—*first*; the *drying oils*, or those that are decomposed by exposure and leave a solid residue; such as Linseed oil, extracted from the seeds of flax (*Linum usitatissimum*), and Rape-seed oil, from different species of *Brassica*.

The drying of Linseed oil is hastened by boiling it with litharge, the Monoxyd of Lead, by which means a vegetable *mucus* is coagulated, that would otherwise impede the drying.

The *second division* of the fixed oils do not dry, but by exposure they absorb Oxygen, become rancid, and are converted into acids. Olive Oil (from *Olea Europea*), Castor oil (from *Ricinus communis*), and Palm oil, are examples. Next follow

THE VOLATILE VEGETABLE OILS.

406. These, generally called *essential oils*, are remarkable for their volatility and odor. They may be arranged in two sub-

The 4th group?

403. Peculiarities in the composition of Oils and Fats? Two sub-groups? First one noticed?

404. Separability of fixed oils into what? Formula why not assignable? General composition?

405. Two subdivisions of fixed oils? *Drying* oils and examples? Use of Oxyd of Lead? Characteristics of the 2d division of fixed oils? The three examples mentioned? What oils are next noticed?

406. Two subdivisions of volatile oils?

divisions; namely, *ternary oils*, or those containing O; and *binary oils*, or those consisting of C. and H. alone.

Among the *ternary oils*, may be mentioned Oil of Cinnamon, $C_{18}H_8O_2$; Peppermint, $C_{11}H_{10}O_2$; Lavender, $C_{15}H_{14}O_2$; and Anise, $C_{20}H_{12}O_2$. The natural oils generally consist of a *fluid* portion, or the oil proper, and a solid part, or Camphor; there being a camphor for each of the oils.

Common camphor (the production of the *Laurus camphora*), is an example of this sort. Its formula is $C_{20}H_{16}O_2$.

407. The *Binary oils* are such as those of *turpentine*, *juniper*, *lemon*, *orange*, *bergamot*, etc. They generally have the equivalents of their C. and H, in the ratio of 5 to 4.

Oil of turpentine, the most abundant of these, is obtained by distillation from the crude turpentine of Pine trees. Its density is .865, and it boils at 312° . It is much used for illumination, for dissolving resins, in making varnish, etc. It is generally called *camphene*.

Dissolved in alcohol, it constitutes common "burning fluid," which burns without smoke, while the volatile oils, owing to the large ratio of C. they contain, all produce a profusion of smoke in burning. All the oils of the same ratio of the components, C. and H., are frequently included in the title, *Camphens*.

408. The ready combustibility of fats and oils, is well known. The volatile oils are more or less soluble in alcohol, and very slightly in water. They rise in vapor, and may mix with air, to form explosive mixtures; and this is true, indeed, of all volatile combustible liquids. The force of the explosion will depend upon the ratio of air to the vapor.

Ill. 447. Specimen of Palm oil.

Ill. 448. Specimens of Volatile oils.

Ill. 449. Combustibility and explosive properties of Volatile oils.

Ill. 450. A dull smoky flame by burning oil of turpentine, and a clear bright one from its solution in alcohol.

Ill. 451. Camphor burned, dissolved in alcohol, etc.

Next come the—

Give examples of ternary volatile oils? Solid and fluid parts of the natural oils? Camphors? Common camphor, source, and equivalent?

407. Examples of Binary volatile oils? The most abundant? Source of oil of turpentine? Density and boiling point? Uses? Common name? Burning fluid? Volatile oils, why smoke when burned? What is included in the term *Camphens*?

408. Combustibility of fats and oils? Solubility of volatile oils? How form explosive mixtures? Other Volatile combustible liquids? Force of explosion? Specimen of Palm oil, 447? Of Volatile oils, 448? What is shown of Volatile oils, 449? Of oil of turpentine, 450? Camphor, 451?

RESINS AND BALSAMS.

409. Resins are solids substances, existing naturally in volatile oils, thus forming BALSAMS, or natural varnishes. They may have originated from an Oxydation of the oils.

Common resin, or Colophony, is the solid residue, in the distillation of oil of turpentine from the crude article. *Pinic*, *Silvic*, and *Pimaric* acids, all having the formula, $C_{40}H_{80}O_4$, are essentially the same as resin, or rather isomeric modifications. Copal and Mastic are other examples of resins; and Amber appears to be a fossil resin.

410. CAOUTCHOUC, or Gum elastic, is a substance existing in the juices of many plants, as the *Jatropha elastica*, and *Hevea Guianensis*. Its composition has not been settled, but it is thought to contain equal equivalents of C. and H. It is dissolved in Ether, Bisulphuret of Carbon, and in certain fluid compounds of C. and H; by which means it is wrought into an immense variety of articles. It is *vulcanized*, or rendered firmer and more permanent, by being incorporated and heated with S, and other substances. This substance, and Gutta Percha, are related to balsams, oils, and resins.

411. GUTTA PERCHA (from the East Indian tree, *Isonandra gutta*), differs from Gum elastic in containing O; also in being readily softened in hot water, by which means it is moulded into any required shape. It consists of several resins. It is soluble in CS_2 , which, by evaporation, leaves it unchanged.

The 5th group of Vegetable Components, &c., comprises the—

NATURAL VEGETABLE ACIDS AND SALTS.

412. These are quite numerous but the most important are the Oxalic, Tartaric, Citric, Malic, and Tannic acids and salts.

OXALIC ACID, $C_4H_2O_6$. Eq. 90.

This acid exists in many plants, and especially in several species of *Oxalis* and *Rumex*, plants known as sorrels, dock,

What substances follow?

409. Source and conditions of Resins and Balsams? What is *colophony*? Acids mentioned in connection with resin? What are Copal, Mastic, and Amber?

410. Source of Caoutchouc? Composition? Solubility? How *vulcanized*? Character of Caoutchouc and Gutta percha?

411. Source of Gutta percha? Differs how from Caoutchouc? Moulded? Composition? Solubility? The fifth group of Vegetable Components and Products?

412. Number of Natural Vegetable acids and salts? The most important? Symbol and equivalent of Oxalic acid, and why? Exists where?

rhubarb, etc. It forms acid salts in these, and gives a sour taste to their juices. Its name is derived from *Oxalis*, the generic name of the wood sorrels.

413. It is manufactured, on the large scale, from the action of Nitric acid upon Sugar and Starch; from a mixture of Nitrate of Potassa, Sugar, and Sulphuric acid; from shavings, etc.

Sugar is converted (by the action of Nitric acid), into Oxalic, Carbonic, and other acids, and the NO_5 is deoxydized into NO_2 , which, absorbing O. from the air, forms Nitrous acid, etc., and thus produces a large volume of reddish brown vapor.

414. It is very soluble in water, from which it may be crystallized. Its crystals contain four equivalents of water, which are expelled by heat. It differs from the other vegetable acids, in not being charred by heat; and is capable of subliming, though in this process it is partially decomposed.

415. Oxalic acid is an active poison, and death has frequently been caused, through mistaking it for Epsom salts, or for some other harmless article. The best antidote is chalk and water, or Lime water, with which the acid forms insoluble Oxalate of Lime.

III. 452. Formation of Oxalic acid by the action of Nitric acid on Sugar.

III. 453. Crystals of Oxalic acid readily fuse in a flask. By continuing the heat, the acid sublimes on the cold parts of the flask, but is partially decomposed, and gives the powerfully pungent odor of Formic acid.

III. 454. Lime water with Oxalic acid, yields a precipitate of Oxalate of Lime.

416. NEUTRAL OXALATE OF POTASSA, $\text{C}_4\text{K}_2\text{O}_8$, is a freely soluble salt formed by neutralizing Oxalic acid with Carbonate of Potassa. It crystallizes in rhombic prisms, and has a bitter taste.

BINOXALATE OF POTASSA, $\text{C}_4(\text{H})\text{KO}_8$, is a natural salt. It causes the sour taste of the sorrels, from which, having been originally extracted, it was called *salt of sorrel*. It is useful for removing iron stains from linen and as a solvent for preparations of Iron.

417. In respect to the formulas of these salts and their acid, it may be noticed, that the older formula of Oxalic acid, was C_2O_3 equal in ratio to C_4O_6 ; either of which represents the anhydrous acid. Adding two equivalents of water, C_4O_6 becomes $\text{C}_4\text{H}_2\text{O}_8$, or ordinary dry Oxalic acid. The salts mentioned, it will be perceived, result from the replacement of one or both equivalents of H, by K. What is called Quadroxalate of Potassa, $\text{C}_4\text{H}_2\text{O}_8, \text{C}_4(\text{HK})\text{O}_8$ is readily formed.

Origin of its name?

413. Manufacturing sources? Reactions between Nitric acid and Sugar?

414. Solubility of Oxalic acid? Crystalizability? Water of crystallization? Differs how from other acids? Sublimation?

415. Poisonous properties of Oxalic acid? Antidote? Oxalic acid, how formed, 452? Action of heat, 453? Lime water, 454?

[416. Symb., properties, formation, crystallization, and taste, of neutral Oxalate of Potassa? Symb., natural source, name, and taste, of Bincoxalate of Potassa?

417. Formulas,—new and old views,—Quadroxalate?]

Ill. 455. Formation of the neutral Oxalate of Potassa, by exactly neutralizing Oxalic acid in solution with Carbonate of Potassa.

Ill. 456. Conversion of the neutral Oxalate, into the *acid* Oxalate or Bin-oxalate, by the addition of a quantity of Oxalic acid, equal to that first employed. The neutral salt may be converted to the *Quadroxalate*, by addition of three times the original quantity of Oxalic acid.

418. OXALATE OF LIME, $C_4Ca_2O_8$, is an insoluble salt, found in many plants, and especially the lichens. The crystals (which contain two equivalents of water), often abound in the bark of trees as in the Locust, and the *Torreyia taxifolia*, or Florida yew.

Oxalate of Lime is an interesting salt, since it is the form in which Lime is precipitated in chemical analysis. The agent most used for this purpose is

OXALATE OF AMMONIA, $C_4(NH_4)_2O_8$, which may be prepared as follows:—

Ill. 457. A strong hot solution of Oxalic acid neutralized with Carbonate of Ammonia: crystallization of the salt by cooling, in beautiful slender rhombic prisms.

TARTARIC ACID, $C_4H_6O_8$. *Eq.* 150.

419. This is abundant in fruits, chiefly as an acid Tartrate of Potassa, from which salt it is extracted.

The acid crystalizes in oblique rhombic prisms and their modifications; is very soluble in water, is intensely sour, and has a strong acid reaction. It takes its name from the *tart* or acid properties of some of its compounds.

Ill. 458. Litmus reddened by $C_4H_6O_8$.

Ill. 459. Bicarbonate of Soda, $NaO.HO.2CO_2$, decomposed by $C_4H_6O_8$, the Carbonic acid expelled, and Tartrate of Soda formed. These are the *Soda powders*.

Ill. 460. Tartaric acid, like other vegetable acids, chars by heat.

420. ACID TARTRATE OF POTASSA, $C_4(H_3K)O_{12}$, called Bitartrate of Potassa, and existing in grape juice, is precipitated by the formation of Alcohol when the juice ferments. Being then impure, it is called *crude tartar*, or *argol*; and when purified is known as *cream of tartar*.

The neutral Tartrate of Potassa is $C_4(H_4K_2)O_{12}$. Tartrate of Potassa and Soda, $C_4(H_4KNa)O_{12}$ is called Rochelle salt. *Tartar emetic* is a Tartrate of Antimony and Potassa, $C_4(H_4K.SbO_2)O_{12}$ in which SbO_2 replaces H.

421. CITRIC ACID, $C_{12}H_8O_{14}$, is the acid of the lemon (*Citrus*

Formation of the neutral oxalate, 455? Acid oxalate, and Quadroxalate, 456?

[418. Symb. and sources of Oxalate of Lime? Why an interesting salt? Reagent for the precipitation of Lime? Symb. equiv. and why of Oxalate of Ammonia?] Symb. of Tartaric acid and why?

419. Tartaric acid abounds where? In what state, and source? Crystallization? Solubility? Name? Litmus, 458? Bicarbonate of Soda, 459? Heat, 460?

420. Symb. and sources of the acid Tartrate of Potassa? [Other Tartrates?]

421. Symb., equiv., sources, name, and properties, of Citric acid?

Limonum), from which it is extracted and takes its name. It crystallizes in modified right rhombic prisms, and therefore in the trimetric system. Its properties are similar to those of Tartaric acid, except that it is tribasic, forming salts with K, in which one, two, or three equivalents of its H. are replaced by K.

Ill. 461. Specimen of Citric acid.

MALIC ACID, $C_4H_4O_6$, is the acid of many fruits, especially the apple (*Pyrus Malus*), whence its name. It assists to give sourness to the stems of the *pie rhubarb*. It forms bibasic salts. Its properties are similar to those of Tartaric and Citric acids; but it is distinguished from them, in giving no precipitate with Lime water.

422. TANNIC ACID, $C_{12}H_8O_{12}$, abounds in the bark of various species of *Quercus* (oak), *Rhus* (sumach), the *Abies Canadensis* (hemlock), etc.; and especially in *gall-nuts* which are excrescences resulting from the puncture of an insect in the *Quercus infectoria*, or dyer's oak, a tree of Western Asia.

Tannic acid, also called tannin, derives its names from the use of substances containing it, in the process of converting hides into *leather* in which Tannic acid plays an important part by combining with the Gelatin of the tissue and forming a permanent insoluble compound.

Tannic acid is a very light, flocculent crystalline solid; soluble in water, and reddening litmus but it has an astringent instead of an acid taste. It is used in medicine; and the vegetable substances containing it are employed in dyeing and ink making.

Ill. 462. Specimen of Tannic acid.

Ill. 463. Precipitations with Tannic acid.

REVIEW.

423. In the division of substances now noticed, comprising the elements of Plants and the products of their tissues and forces, it has been seen that the groups are quite characteristic.

The first group,—the Neutral Ternaries, embrace the substances making up the great mass of the vegetable kingdom and its most abundant products:—Cellulose, either pure or mod-

Acid in apples, name, and why?

422. Symb. and sources of Tannic acid? Name? Leather? Properties? Taste and uses of Tannic acid? Specimen, 462? Precipitations, 463?

423. What division of the Organic series of substances has now been noticed? First group how designated? Share of the Vegetable kingdom? Cellulose forms what?

ified, constituting its framework and main bulk ; and Starch, the Sugars, and Gum, its largest additional material.

It has been seen, that all the substances of this group, contain Oxygen and Hydrogen in the ratio of 8 to 1, as in water ; and these, in combination with Carbon.

424. The mutual convertibility of these, to serve the various purposes of vegetation has been referred to :—as ; the gummy solution or mucilage becoming organized into Cellulose ; modified into Cane Sugar in the stalks ; deposited in starchy grains in the underground stems, or in the seeds ; or converted into Grape Sugar in the juicy fruits :—also the Starch or Sugar of the seeds, supplying the material, in germination, for the first cell walls of the young plant, before it has the power to manufacture its own aliment.

It has been seen too, that the redundant products of the vegetable world, which belong to this division, are available, as Starch, Sugars, and Gum, to the animal world, whose economy they can assist by supplying the elements of respiration ; that is, the fuel for animal heat ; though incapable of being employed in building the animal tissues, and therefore innutritious.

425. In the second group of this division, the Neutral Quaternaries have appeared if not as *abundant*, as least as *important*, as any that have received attention.

Again, in these, as in the previous group, is remarked, the principle, that different substances may have the same Chemical elements, and these, combined relatively to each other, in the same ratio. Again, too we see in the Glutin, Legumin, and Albumin, substances that for the purposes of plants are transformable into each other ; but, in these substances we do not recognise, as with the previous group, permanent elements of the vegetable structure : instead of this we find the protoplasm, the first shaping material, which is but a modification of the different members of this group, constituting a lining to the cell walls, so long as the cells serve as laboratories for the modification of matter or for the multiplication of themselves ; but as these cells lose their activity, we find the substance in question transformed to other parts, and again serving the same pur-

What constitutes the additional material ? Ratio of O. to H. in this group ? Other element ?

424. What are the particulars in respect to the mutual conversion of these substances in plants, and objects of this conversion ? Use of the redundancy ? What purposes do they, and what do they not serve for animals ?

425. Designation of the *second group* ? Abundance and importance ? What is the *first* principle remarked in reference to the *two groups* ? The *second* ? Members of the *second group* ? Permanent elements of the vegetable structure ? What is *protoplasm* ? Its offices and transformations ?

pose; and finally it passes into the seed and is deposited, to begin once more a course of activity, when the infant plant starts for an existence of its own.

Then, beside playing a part, *temporarily*, in the *organization* of the *vegetable* world, we find the same substances becoming the aliment of another series of existences, and constituting the *permanent basis* of the *organization* of the *animal* world.

426. In the third group we discover, first, as Morphine, Quinine, Strychnine, etc., energetic, chemical agents, approaching some of the active inorganic compounds in properties; substances not generally prevailing in the vegetable world, but only occurring in a few individuals, upon which, by their properties, they render distinction.

Then, since we can find, in the economy of the several plants, no use for the principles that characterize them; believing always, that in every created thing there is *some design*, *some purpose* to be *served*; we experiment upon the effect of these energetic principles, on the animal economy, and discover, *when their properties, and effects, are fully studied, and carefully weighed, valuable agents* in the treatment of our own irregularities and diseases.

427. And if we find these powerful principles comparatively rare, and sparsely scattered, which, in ignorant hands are dangerous, and in malicious ones, terrible; we soon discover, in almost every single species of plant, some mild, yet valuable characteristic principle, of which Salicin and Amygdalin are examples, the properties and uses of which all may safely investigate, and the application of which even brutes seem, in some cases, to have learned.

This subdivision of the group, as well as the highly interesting one that follows, comprising the Original Vegetable Coloring matters, seems as yet almost a desert region, into which investigation has here and there made some exploration.

428. Then, in the fourth group of Inherent Vegetable Oils, Resins, and Balsams, are exhibited highly characteristic properties and peculiarities.

We have substances composed mostly of Carbon; with, it is

What part do Glutin, etc., play in the animal world?

426. Examples of the *third group*? Active properties, and prevalence in plants? Use for Morphine, etc., in the vegetable economy? What use is discovered?

427. Powerful substances in ignorant or malicious hands? Other, more common, and milder principles? Examples? Extent to which these substances and certain coloring matters have been investigated?

428. Designation of the fourth group? Peculiarities in composition?

true, a fair ratio in *equivalents*, of Hydrogen; but still comparatively little *in weight*, while an equivalent or two of Oxygen barely appears, or is entirely absent.

Take, for example, common camphor, $C_{20}H_{16}O_2$, which is but a solid volatile oil; and we have 20 equivalents of Carbon, or 120 parts by weight, while the 16 equivalents of H. only weigh 16; and the two equivalents of O. also weigh 16; so that 152 pounds of Camphor gum, contain 120 pounds of pure coal, 16 pounds of H, and 16 of O; or, $\frac{15}{19}$ C; $-\frac{2}{19}$ H; $-\frac{2}{19}$ O.

And then, in oil of Lemons, there is no O; the ratio of equivalents is C_5H_4 , or 30 pounds of Carbon, and 4 pounds of Hydrogen.

429. These substances, so rich in C, are necessarily combustible.

Then, it was noticed that the oils are divided into the *fixed* and the *volatile*: and the fixed oils consist of the *siccescent* or *drying* oils, like the *linseed*; and *acescent* or *souring* oils, like olive oil; while the volatile oils are divided into the ternary, like oil of Peppermint, $C_{21}H_{20}O_2$; and the binary, like oil of Lemon.

Then we have solid oils or fats, which separate from the naturally fluid fixed oils, as the Margarin from Olive oil. Also solid oils, or Camphors from the volatile oils, as common Camphor.

Then the sub-group of Resins, such as Colophony, Copal, and Mastic, by solution in volatile oils, constitute natural Balsams, as Crude Turpentine, containing Colophony dissolved in Oil of Turpentine. The valuable products, Caoutehoue, and Gutta Percha, seem to belong here.

430. In the fifth Group are the Inherent Vegetable Acids and Salts; as, Oxalic acid, and the Oxalates; Tartaric acid, and the Tartrates; Citric acid, and the Citrates; Malic acid, and the Malates; and Tannic acid, and the Tannates.

In order not to complicate the subject by reference, at the same time, to inherent vegetable products, and to artificially formed compounds, some of the known salts of acids of this group may be described under a different general head.

These acids and salts are, many of them, quite generally distributed. Oxalic acid is found in the juices of many plants;

C, H, and O, in Camphor? In oil of Lemon?

429. Why combustible? Two divisions of the oils, etc.? Examples of fixed oils? Subdivisions of the fixed oils? A *siccescent* oil? An *acescent* one? Subdivisions of the volatile oils, and examples? Separation of solid fat from oils, and example? Examples of resins? Balsams?

430. Designation of the fifth group? Examples? Distribution of Oxalic acid and Oxalates?

and crystals of Oxalate of Lime, are very frequently deposited in the cells of tissues, as in the bark. This, then, is one of the salts forming the *raphides** of the botanists, so interesting to microscopic observers and vegetable physiologists.

Tartaric, Citric, and Malic acids, abound in fruits, in a free state; and also form, as far as bases are present, a variety of acid salts.

These different groups of Inherent Vegetable Components and Products, then, embrace substances *formed by the agencies of plants, from the mineral elements absorbed from the earth and the air.*

431. The composition of vegetation is then readily seen, from a retrospect of these groups.

The greater part of the vegetable mass is made up of Cellulose, which is organized in various ways, to form all the proper tissues of plants; whether we consider the strong fibres of the flax, the compact structure of the oak, or the delicate network of the petals of flowers. In the firm wood, forming the trunks of trees, the cells of this tissue have their walls compacted, and their cavities diminished, by a deposit of a merely modified *form*, of this tissue, with a slight change in its composition, and the addition of some earthy salts.

432. *Then, second, in order of abundance, of the vegetable products, we find Starch*, deposited in the cellular tissue, in large quantity in certain parts, as in seeds, roots, or subterranean stems, and in smaller quantity, even in the woody cells.

We get an idea of the abundance of this substance, as a vegetable product, when we consider that Starch forms from 60 to 66 per cent. in wheat and rye flour, 40 to 50 per cent. in that of barley, sometimes as much as 78 per cent. in Indian meal, and 70 per cent. of potatoes, freed from water.

The pith of palm trees, particularly species of *Sagus*, furnishes *sago*; the *Maranta arundinacea*, of the West Indies, furnishes *arrow-root*; the *Jatropha Manihot* of the tropical regions of America and Africa, is the source of *cassava* and

* Greek, *raphides*, needles: A term originating with the slender crystals found in the cells of some plants, and extended now to all crystals in similar situations.—ASA GRAY.

Raphides? Other acids and their states? Formation of the Inherent Vegetable Components and Products? How is the *composition* of the vegetable world seen?

431. What makes up the greater part of the bulk of plants? Flax-fibre, Oak-wood, and the petals of flowers?

432. Starch in the order of abundant substances? Where found? Percentage of Starch in flour and meal? Potatoes? Sago, arrow-root, etc?

tapioca; all of which are merely modifications of Starch, often imitated by manufacturing over, common potato Starch.

433. Next after Starch in abundance, viewed as a final product we have Gum; but if we consider the mucilaginous portion of the juices of plants, and the jellies of fruits to be merely dissolved Gum; this substance in point of abundance in the vegetable world, will, perhaps, stand before Starch.

434. Then follow the Sugars; Cane Sugar in the stalks, and Grape Sugar in the fruits; both crystalizable forms of sugar, beside a viscous uncrystalizable modification, generally pervading different parts of plants.

Then the various Vegetable Acids, and their salts; the Tartaric, Malic, Citric, Oxalic, Tannic, etc., generally abound some in stalks and some in fruits.

It may be remarked that in respect to composition, all these acids contain a larger ratio of Oxygen to Hydrogen than exists in water. Thus Oxalic acid has 8 Equivs. of O. to 2 of H. In Tartaric acid the ratio is O_{12} , to H_6 ; in Citric O_{14} , to H_8 ; in Malic O_{10} , to H_6 ; and in Tannic acid even which approaches the class of resinous acids, it is O_{32} , to H_{21} .

The Oily principles, of the fixed and volatile divisions, and the Resins, and Balsams, are also extensive vegetable products.

Finally, there are the Peculiar Principles of plants; the Salicin, Phloridzin, Emetin, Amygdalin, etc., substances extremely extensive in number, but comparatively small in quantity; as well as the powerfully active principles, still less abundant, of the sub-group of the Alkaloids; Morphine, Strychnine, Quinine, Caffeine, Nicotine, etc.

435. While, then, it has been impossible to notice many important substances and even *classes* of substances, existing in the vegetable world; and while we have only given attention to the most remarkable of each class noticed; we still have an idea of the compound elements of this extensive kingdom.

Then it will be next in order to consider the

ANIMAL COMPONENTS AND PRODUCTS.

436. These, as well as those of Vegetables, may be arranged in groups.

433. Order, in abundance of Gum considered as a final product? As existing in the juices of stalks and fruits?

434. What sugars follow, and what is said of them? What are mentioned next as quite abundant? Examples? [Composition of the acids?] Resins and Balsams? Number and quantity of Peculiar Principles and Alkaloids? Examples of both? Can you now recapitulate the general composition of the Vegetable Kingdom?

435. Substances unnoticed? What are next in order?

436. Groups?

The first in importance and the most extensive is the group of

NEUTRAL QUATERNARIES.

These may be divided into two sub-groups, namely, 1st, the *Protein*, and 2d, the *Gelatin* compounds.

I.—THE ANIMAL PROTEIN COMPOUNDS. $C_{24}H_{47}N_3O_8$.

437. These, as has before been hinted, are similar both in composition and properties to the vegetable Neutral Quaternaries. The most abundant and important of these are the three known as Fibrin, Albumin, and Casein.

The first corresponds to Glutin which has been called *vegetable* Fibrin; the second to *vegetable* Albumin; and the third to Legumin, or *vegetable* Casein; and all these substances, both animal and vegetable, are of such pre-eminent importance in the organic world, as to have received the title of PROTEIN compounds; from the Greek, *proteuo*, *I hold the first place*.

438. FIBRIN, is the material of animal *muscular tissue*, otherwise called, "*lean meat*,"* and properly *flesh*, as distinguished from fat.

It coagulates from drawn blood, forming what is termed the *clot*, the fibrous arrangement of the particles of which as well as of those of lean flesh, gives to Fibrin its name.

It is insoluble in water, but, is readily dissolved in water containing a little Acetic or Chlorohydric acid, as well as by many other agents. When washed it remains a colorless substance drying to a hard semi-transparent condition. Fibrin also occurs in the fluid of the *thoracic* duct.

439. ALBUMIN is seen nearly pure in the white of eggs, but also forms a part of the yolk. It constitutes a considerable portion of blood, as well as of the *chyle* from which blood is formed. Unlike Fibrin, it is readily dissolved in cold water. By heat it coagulates, as well as by the action of metallic solutions; by

* The word *flesh* is now invariably used by Chemical and Physiological writers to signify *pure lean flesh*.

First group of Animal components and products, and what is said of it? Two sub-groups of the Neutral Quaternaries? Which is first described? Symbol of the Animal Protein compounds?

437. These are similar to what? The three most abundant? Which severally correspond to the similar vegetable principles? Why called Protein compounds?

438. What is Fibrin? Proper use of the word flesh? Fibrin from blood? Origin of the name of Fibrin? Solubility? Appearance and properties when washed? Where else found?

439. In what is Albumin found? Solubility? How coagulated?

Alcohol, and by a variety of chemical agents. When coagulated it is insoluble in water. The properties of *animal* Albumin are generally the same as those of *vegetable*. Eggs merely exhibit a more concentrated form of this substance, but still containing a large ratio of water.

440 CASEIN abounds in milk in which it is probably held in solution by free Soda. By acids it is coagulated, and also by several organic substances.

In cheese-making, the Casein is often coagulated by means of infusion of *rennet*. Rennet is the stomach of some animal, usually that of a calf, the inner coat of which communicates this property.

The curd of well skimmed milk is nearly pure Casein.

The animal modification of Casein and Legumin,—the vegetable form, have, it is seen, a general agreement in properties.

440, *a*. Flesh, white of eggs, and non-unctuous cheese, though they are severally and essentially composed of Fibrin, Albumin, and Casein, and may be taken as representatives of those substances, always leave, when burned, some ash, or fixed matter. Fibrin is, too, an *organized* substance, that is, its particles have been arranged in their peculiar form, under the influence of the vital force. In this respect also *vegetable* Fibrin or Glutin somewhat resembles the animal modification.

441. PROTEIN. When any of the animal or vegetable forms of the Protein substances are properly dissolved and precipitated, the dried precipitate, a yellowish brittle substance, has a uniform composition from every source; it is called Protein.

Protein itself, and the animal Protein substances,—the Fibrin, Albumin, and Casein, have the same composition. This composition is very well represented by the formula, $C_{24}H_{17}N_3O_8$, although different formulas have been given.

This formula is the same as for Glutin, vegetable Albumin, and Legumin, and is to be understood in the same sense; the Sulphur and Phosphorus, neither of which are in quantity to

Solubility when coagulate? Animal and vegetable forms? Condition in eggs?

440. In what is Casein found? How in solution? How coagulated? How in cheese-making? What is *rennet*? The curd of milk? Animal and vegetable forms?

440, *a*. Composition and result of burning flesh, white of eggs, and non-unctuous cheese? Fibrin, why said to be organized? Glutin, in this respect?

441. Source and properties of Protein? Composition of Protein and of all the Protein substances? Formula and its meaning? Can you from this formula tell the parts by weight of the C, H, N, and O, in the Protein compounds? Other substances of the same formula? The formula is understood in what sense?

form an equivalent, being represented by Oxygen, and Nitrogen; and other substances regarded as impurities.

441, *a*. All these substances, therefore, both animal and vegetable, when converted into any of the animal modifications are still of the same composition. As the result of the digestive process, they take first the Albuminous or soluble form. The Albumin is modified into the Casein of milk, or into the Fibrin of blood or flesh, not by a change in its ultimate chemical constitution, but by a change in the arrangement of its particles.

The Fibrin may afterward be redissolved and converted to the Albuminous condition; the Casein may undergo a similar transformation, when milk, or cheese becomes the food of another animal.

We may now proceed to notice the second sub-group of the neutral animal quaternaries; namely,

THE GELATIN COMPOUNDS.

442. The chief of these are Gelatin and Chondrin.

GELATIN, $C_{24}H_{20}N_4O_8=284$, is the substance forming the tissues of *skin, ligament, tendon, bone, cellular membrane*, and animal tissues generally, except the muscular tissue or fibre, and that of *cartilage*, or uncompact bone.

In these tissues, it is organized and insoluble in cold water. The tissues dissolve in boiling water, and form a jellyish mass on cooling, known as *glue*. Common glue is, then, but dissolved Gelatin, somewhat impure; the organization of which has been destroyed, but which has undergone no change in chemical composition.

443. *Isinglass* (not *mica*), is a purer form of dissolved Gelatin prepared from the air-bladder, skin, stomach, etc., of fishes, particularly of the sturgeon.

One part of Gelatin dissolved in twenty-five of water, forms a jelly.

Tannic acid, as already noticed (Art. 422), precipitates Gelatin, and the salts of Mercury have the same effect.

441, *a*. When any of the Protein compounds is converted into another, what is its composition? First form in the digestive process? Albumin, how converted into Casein and Fibrin? Changes which Fibrin and Casein may undergo? What sub-group follows?

442. The chief Gelatin compounds? Symbol and meaning? Sources of Gelatin? What tissues do not contain it? What is cartilage? State of Gelatin in the tissues? Effect of boiling water on tissues? What is *glue*?

443. Isinglass and sources? How little Gelatin dissolved in water will form a jelly? Gelatin, how precipitated?

Gelatin is extensively employed in the arts for cementing, clarifying, and other purposes. It forms the different prepared animal jellies, but as an article of food it is of little or no value.

That it is not a flesh forming substance, is inferred by its not being wasted in starvation; it differs from flesh in composition, and is not a proper element of blood. The animal system has the power to form it from the Proteïn substances.

CHONDRIN differs slightly from Gelatin in composition, and, unlike that substance, is precipitated by solution of Acetate of Lead, or of Sulphate of Alumina and Potassa. It is derived from *cartilage*.

Deferring further notice of the substances of the group now described, we may pass to the—

PECULIAR ANIMAL PRINCIPLES.

444. These are of very diverse character and composition, though much less numerous than the *vegetable* principles. The most important are the following:—

LACTOSE, or *Milk Sugar*, $C_{24}H_{40}O_{20} = 324$.

This sugar is the cause of the sweetness of milk, and is obtained from whey* by evaporation and crystalization.

The crystals, which are generally small square prisms, contain four equivalents of water, which are expelled by a temperature of 212° . These crystals are soluble in six parts of cold water; and thus this Sugar seems less intensely sweet than the more soluble ones. Possibly, however, the mere difference in solubility may not account for the different sweetness of the Sugars; but this seems an obvious explanation.

445. When the Lactose of milk is converted naturally into Lactic acid, the milk is said to sour.

Lactose corresponds to the vegetable Sugars in composition,

* Whey, as is well known, is the fluid residue of milk, after the butter and cheese have been separated.

Uses of Gelatin? Why considered to be non-flesh-forming? Uses in food? Source in the animal system? Composition, properties, and sources of *Chondrin*? What group of substances follows?

444. Diversity and number of the *animal Principles*? First one described? Symbol and equivalent, and other name of Lactose? Milk, why sweet? Source of Lactose? What is whey? Shape, water of crystalization and solubility of the crystals of Lactose? Effect of a temperature of 212° ? Milk sugar, why less sweet than others?

445. How does milk sour? Correspondence and composition of Lactose, and the other sugars?

consisting, like them, of C. combined with O. and H; and the latter two, in the same ratio as in water, that is one equivalent to one; or 8 to 1, in parts, by weight. Lactose is *isomeric*, when dry, with Starch, Gum, and Cellulose; and when crystallized with anhydrous Grape Sugar.

446. CREATIN, $C_4H_6N_3O_4$, is a neutral substance probably existing in the *flesh fluid*, a liquid that may be washed from finely cut flesh, and from which, by a simple process, colorless crystals of Creatin are obtained. Creatin is readily changed into—

CREATININ, $C_4H_7N_3O_3$, an alkaline basic substance which also forms colorless crystals. Both of these substances are thought to exist in the flesh fluid, and to be present in broth. They are regarded as elements of urine.

447. PEPSIN is a substance present in the saliva, and the gastric juice. It is a Quaternary substance consisting of C, H, O, and N; and has the power of converting sugars into Lactic acid, by means of which, the Protein compounds may be dissolved.

448. HEMATOSIN, $C_{44}H_{22}N_3O_6$, is the coloring matter of blood. Nearly seven per cent. of Iron is associated with it, but this may be separated without a destruction of the color.

ALLANTOIN, $C_4H_6N_4O_6=158$, is a substance found in the liquid of the *amnios* of bovine animals, and crystalizes in colorless prisms.

449. UREA, $C_2H_4N_2O_2$, is a substance of great importance. It is a characteristic element of urine, and crystalizes in transparent, colorless, four-sided prisms, which are soluble in an equal weight of cold water.

It is inodorous, has a saline taste, is permanent in dry air, and is without action on test colors; but is regarded as of an alkaline character, having basic properties, and being capable of combining, like Ammonium, with O. and acids, such as the Nitric.

The Symbol of the Nitrate of Urea is $(C_2H_4N_2O_2) O, NO_5$, corresponding

Isomeric bodies?

446. Symbol, source, and properties of *Creatin*? Into what is it changed? Symbol, and properties of *Creatinin*? Broth?

447. In what is *Pepsin* found; its composition, and properties?

448. What is *Hematosin*? Composition? [Symbol, equivalent, source, and properties of Allantoin?]

449. Symbol and importance of Urea? Crystallization and solubility? Odor, taste, and permanency? Action on colors? Why regarded as alkaline? [Symbols?]

to the symbol of Nitrate of Ammonia, $(\text{NH}_4) \text{O}, \text{NO}_3$. The results of its decomposition are hereafter to be considered.

Next in order comes the group of—

ANIMAL ACIDS AND SALTS.

450. These may be divided into the three sub-groups: 1st, those destitute of Nitrogen; 2d, those containing N. alone, or N. and P; 3d, those containing N. and S.

SUB-GR. 1. TERNARY ACIDS (containing C, H, and O).

The chief of these are the Formic, Lactic, Benzoic, and Cholalic.

FORMIC ACID, $\text{C}_2\text{H}_4\text{O}_2$, is so named, since it is a secretion of the red ant (*Formica rufa*), but it may be produced in a variety of ways, as by the reactions between Sugar, Bichromate of Potassa, and Sulphuric acid; and by the decomposition of Oxalic acid by heat (Art. 415).

It is also a vegetable product, being the cause of the stinging sensation produced by the nettle (*Urtica urens*, etc.), as well as that from the bite of the ant.

451. When pure, it is at common temperatures a colorless liquid, boiling at 210.2° , and yielding a most powerfully pungent odor. At 32° it crystalizes in brilliant plates. It is a fuming corrosive, blistering acid; its vapor burns with a blue flame.

III. 464. Production of dilute Formic acid, by distillation, from 8 parts of Bichromate of Potassa, 3 of Sugar, and 32 of water, to which 8 parts of Sulphuric acid have been slowly added.

III. 465. Formate of Lead, produced by action of dilute Formic acid, on Acetate of Lead. From this Lead salt, anhydrous Formic acid is obtained by the action of HS.

452. LACTIC ACID, $\text{C}_{12}\text{H}_{12}\text{O}_{12}$, has been referred to, as the cause of the souring of milk, by a change in its Sugar, or Lactose. Both these substances take their name from the Latin, *lac*, milk.

It may be produced in a variety of ways; but, at present, it

What group of substances follows?

450. Three divisions of animal acids? Division first noticed? Chief of the ternary animal acids? Symbol, equivalent, name, and sources of Formic acid? Nettles and ants?

451. Odor, form, and boiling point? Properties? Production, 464? Formate of lead, 465?

452. Symbol and equivalent of Lactic acid? What is soured to produce it? Names? Production?

will only be referred to as existing in eggs; and, as an element of the *gastric juice*, or the peculiar fluid of the stomach, assisting to give to that agent, the power of dissolving Fibrin, or lean meat, and of thus effecting digestion. Lactic acid is a sour sirupy liquid.

453. BENZOIC ACID, $C_6H_5O_2$, is an animal product found in urine, but is abundantly derived from the resin, *benzoin*, a product of the tree, *Styrax benzoin*, of the East Indies.

Benzoic acid, it will be seen, presents, in its composition, a variation from the principle referred to (434), in reference to the acids of the Tartaric acid group; for, while those acids all contain more equivalents of O. than of H, this has more of H. than of O.

Benzoic acid crystallizes in slender, snow-white crystals; is soluble in water; has an aromatic acid taste; and is inodorous. By a moderate heat it is sublimed unchanged. The odor generally noticed in connection with it, is due to a volatile camphor.

Ill. 466. Benzoic acid sublimed from benzoin by heat.

454. CHOLALIC ACID, $C_7H_5O_2$, is an acid thought to exist in the bile. It crystallizes in colorless octahedrons, and is almost insoluble in water, but is readily dissolved by Alcohol.

Next in order are

SUB-GR. 2. THE NITROGENIZED ANIMAL ACIDS,

And those containing Phosphorus. The chief of these are the Uric, Hippuric, Hyocholic, Inosinic, and Cerebric.

455. URIC ACID, $C_5H_4N_2O_3$, as its name indicates, is contained in Urine, and in the solid exuviae of carnivorous birds. It is moderately soluble, and feebly acid.

It is important, since it, and its salts, as the Urate of Ammonia, and the Urate of Soda, are unnaturally deposited, in the diseases known as *gout*, *gravel*, and *stone*.

456. HIPPURIC ACID, $C_8H_7NO_3$, is similar to Uric acid in origin and properties; but abounds more with *herbivorous* animals, and takes its name from *hippos*, a horse.

457. CHOLIC ACID, $C_{25}H_{43}NO_5$, is considered to exist in the bile, in combination with Soda. This acid forms slightly soluble, white, silky crystals. Its name is derived from the Greek, *chole*, bile. The bile of swine contains,

HYOCHOLIC ACID, $C_{54}H_{113}NO_{10}$.

458. INOSINIC ACID, $C_{10}H_{12}N_4O_{12}$, is a soluble acid of the flavor of broth, furnished by the *flesh fluid* (486).

Eggs? What is gastric juice? Use of Lactic acid in *gastric juice*? Properties?

[453. Benzoic acid, symbol, and sources? Benzoin, and source? Ratio of O. to H? Properties of Benzoic acid?] Sublimation, 466?

[454. Symbol, sources, and properties of Cholalic acid?]

What acids follow? Chief Nitrogenized animal acids.

[455. Symbol, source, properties, and importance of Uric acid?

456. Symbol, origin, properties, and source of Hippuric acid?

457. Symbol, source, and properties of Cholic acid? Hyocholic?

458. Symbol, source, and properties of Inosinic acid?]

459. CEREBRIC ACID, is contained in the brain, and in nervous matter. It is a fatty acid containing Phosphorus. A similar, if not the same substance, exists in the blood.

SUB-GR. 3. ANIMAL ACIDS CONTAINING SULPHUR.

These are chiefly the Sulphocyanic and Choleic acids.

460. SULPHOCYANIC ACID, C_2HNS_2 , in a saline form, is present in saliva. It will be better understood after the Cyanogen compounds have been attended to.

461. CHOLEIC ACID, $C_{22}H_{45}NO_{14}S_2$, is also one of the characteristic acids of the bile (486).

The substances next to be noticed form a group here designated—

SUB-GR. 4. WAX AND THE ANIMAL OILS AND FATS.

462. The difference between a *fat* and an *oil* is, that an oil is more or less *liquid*, at common temperatures, and a fat is *solid*.

Wax, or *beeswax*, is the secretion of the bee (*Apis*), and is of the same character as other animal fats.

There is, however, *vegetable wax*, one variety of which is commonly called *bayberry tallow*; the product of the wax myrtle (*Myrica cerifera*), and several other species of the same genus. Different trees of the Palm kind, produce a similar substance; and wax is found, also, in pollen, and on leaves and fruits.

463. The substances of this group are *ternary*, consisting of the three elements, *Carbon*, *Hydrogen*, and *Oxygen*.

The number of equivalents of C. and of H. is nearly equal, and much larger than that of O; and in this respect, the animal oils and fats, closely resemble the vegetable. An animal oil, or fat, is also, like those of the vegetable kingdom, frequently separable into several different oils or fats, of different degrees of consistency, and of different composition and properties.

464. The liquid portion of fat is generally called *olein*, but

[459. In what is Cerebric acid found? Its character, and what does it contain?]

Designation of sub-group 3? What are the chief animal acids containing S?

[460. Sulphocyanic acid, symbol, and where found?

461. Choleic acid, symbol and source?]

What substances belong to the fourth group?

462. Difference between a fat and an oil? What is wax?

[Vegetable wax, and sources.]

463. Composition of Wax, Fats, and Oils? Ratio of C, H, and O?
Separability of the animal oils and fats?

464. Olein.

the term is applied to substances of somewhat variable composition.

465. MARGARIN is a more definite term for a solid fat, existing in that of *man*, of the *ox*, *swine*, *sheep*, and various other animals.

Margarin is freely soluble in Ether, and fuses at 116° .

466. STEARIN is also a definite solid fat, much less soluble in Ether than Margarin, and fusing at 130° .

467. BUTYRIN is a colorless oil, having the odor of melted butter, and extracted from that substance. Butter contains also other fatty substances, not perfectly investigated, but known as *Caproin* and *Caprin*; as well as Stearin and Margarin. *Hircin* is an oil existing in mutton suet.

468. PHOCENIN is an element of the oil of the *porpoise* (*Delphinus phoca*).

DELPHININ is an element of *whale* and *dolphin* oil.

469. CHLORESTERIN, $C_{52}H_{110}O_4$, is a fat existing in bile and brain. It sometimes forms *biliary calculi*, or concretions in the gall bladder.

SEROLIN is a fat found by *Lecanu*, and others, in the blood.

470. CANTHARIDIN, $C_{10}H_8O_4$, is a fatty substance constituting the active principle of the Spanish fly (*Cantharis vesicatoria*).

These different fats and oils are generally compounds of some peculiar fatty acid, with *Glycerin*, as will be hereafter noticed.

471. CERIN, or *Cerotic acid*, $C_{54}H_{94}O_4$, is the principle in wax (*cera*) that is soluble in alcohol; while MYRICIN is the insoluble part, and being abundant in the myrtle-wax, from species of *Myrica*, has thence derived its name.

472. The principle substances known to exist in animals, have now received attention. They have been arranged in four groups, namely: 1st, Animal Neutral Quaternaries; 2d, Peculiar Animal Principles; 3d, Animal acids and salts; and, 4th, Wax, and the Animal Oils and Fats.

Gr. 1. *The Animal Neutral Quaternaries*, embracing two subgroups: 1st, the *Animal Protein* substances, Fibrin, Albumin, and Casein; and, 2d, the *Gelatin substances*,—Gelatin and

465. Margarin? 466. Stearin? 467. Butyrin? Caproin, Caprin, Hircin? 468. Phocenin? Delphinin? 469. Chloresterin? Serolin? 470. Cantharidin? Compound elements of these fats? 471. Cerin? Myricin?

472. What have now been attended to? How many groups have they formed? Name the four groups? The members of group 1? What subgroups in gr. 1?

Chondrin. These consist of the four elements, C, H, N, and O.

Gr. 2d. *The Peculiar Animal Principles*: Lactose, Creatin, Creatinin, Pepsin, Hematosin, Allantoïn, and Urea; all quaternary substances, except the first, and consisting of the four elements, C, H, N, and O.

Gr. 3d. *Animal acids and salts*, consisting of three sub-groups:

1st. The *Ternary or Non-nitrogenized*—Formic, Lactic, Benzoic, and Cholic acids.

2d. *Those containing Nitrogen, or N. and P.*—Uric, Hippuric, Cholic, Hyocholic, Inosinic, and Cerebric acids.

3d. *Those containing Sulphur*—Sulphocyanic, and Choleic acids; all these contain Oxygen and Hydrogen.

Gr. 4th. *Wax, and the Animal Oils and Fats*—olein, Margarin, Stearin, Butyrin, Caproïn, Caprin, Hircin, Phocenin, Delphinin, Chloresterin, Serolin, Cantharidin, Cerin, and Myricin; the ultimate elements of which are Carbon, Hydrogen, and Oxygen.

From a review of these, and some further explanations, we may sum up the

GENERAL COMPOSITION OF ANIMALS.

473. In the animal as well as the vegetable kingdom, *one of the chief constituents of the living being, is water in its proper form.*

It is well known that wood and vegetable substances, generally, contain so much water even in their solid parts, that when dried they lose a very considerable portion of their weight. The ratio of water, with different substances, varies extremely; some being nearly free from it, and others consisting almost entirely of it.

474. The *juices of plants* are, of course, mostly water, in which comparatively small quantities of other substances are dissolved.

Besides this, it was seen that such abundant substances as Cellulose, Starch, Gum, and Sugars, consist wholly of Carbon or coal, combined with the elements of water, and these *united*

Members of gr. 2? Sub-groups of gr. 3, and their members? Of gr. 4? What is next generally summed up?

473. A chief constituent of plants and animals? What well known? Ratio of water?

474. Juices of plants? Water, as water, in Starch, Cellulose, &c.

in the same ratio as in water. While it can not be said positively that water exists, as such, in these substances, still this is very probable; not merely because of the ratio of the O. to the H.; but, also, because these substances are so readily convertible into each other; which would certainly be affected more easily, if there were but the affinity of water for Carbon to be overcome.

475. And so with animals. All their tissues shrink, and lose weight largely by drying; while blood, milk, chyle, bile, sweat, &c., are generally more than three fourths water, so that this substance is seen to form a very large share of living animal and vegetable bodies.

476. We may next proceed to notice the constituents of the various obvious parts of the animal frame.

THE BONES. These consist chiefly of Phosphate of Lime (Arts. 54 and 225), and Carbonate of Lime. Their tissue is Gelatin.

Bones may be regarded as consisting of two distinct parts; each having the outline, or shape and size of the bone.

Ill. 467. A bone that has been burned in the fire. It consists merely of the mineral part, chiefly Phosphate and Carbonate of Lime, and is extremely brittle.

Ill. 468. A bone that has been soaked in dilute Chlorohydric acid. It is perfectly soft and flexible, but has, like the other, *the shape of the original bone.* It is almost entirely Gelatin; and, if allowed to dry, will become hard and inflexible, but put into warm water, dissolves and forms *glue.*

477. The material to form the bones has been brought to them by the blood; the earthy substances having been contained in the food; and the Gelatin having originated with the Protein compounds.

478. **THE CARTILAGES.** These organs, serving the purpose of bones, but of a more pliable character, have a composition similar to bone. They contain a much smaller ratio of Phosphate and Carbonate of Lime; and their organized tissue is Chondrin (443) instead of Gelatin.

479. **THE MUSCLES.** These, besides *the flesh fluid* (486), they contain, consist almost entirely of Fibrin (438); since when the flesh is burned it leaves but a slight trace of ash.

475. Water in animal tissues and fluids?

476. What is next noticed? Bones and their tissue? Two parts, and shape? *Ill. 467? 468?*

477. Sources of the material of bones?

478. Composition and use of cartilages? Their tissues?

479. Composition of the muscles?

This Fibrin has been derived entirely from animal and vegetable Protein compounds, coming originally from the vegetable kingdom.

480. THE SKIN, *cellular tissue, ligaments, tendons, membranes, &c.* are composed mostly of Gelatin; having some fat deposited in the cells.

481. THE BLOOD. This body is more than three fourths water. In this liquid are dissolved a number of salts, such as Chlorids, Carbonates, and Phosphates; being salts of the metals Potassium, Sodium, Calcium, Magnesium, and Iron; as well as some Sesquiöxyd of Iron; altogether usually from six to eight tenths of one per cent.

These substances give the blood little or no color. Besides holding these solids in solution and diffusion, *fresh arterial blood* contains dissolved a large share of gas, which is chiefly a mixture of about four parts of O. to one of N.

482. The other substances are chiefly as follows:

Red blood globules. These are roundish microscopic bodies, (from $\frac{1}{10000}$ to $\frac{1}{3000}$ of an inch in diameter in man,) and are of different shapes and sizes in different animals.

These globules are colored with a four or five hundredth part of *Hæmotosin* (448), associated with about an equivalent of Iron; and the remainder of them consists of a Protein substance, not essentially different from *Albumin*. The globules form from twelve to about fourteen per cent. of healthful blood.

483. *Albumin* constitutes about seven per cent; *Fibrin* about one fifth per cent; then *Serolin* (469), *Common fat*, *Chloresterin* (469), and probably *Ceribric acid* (459), altogether form about one sixth per cent.

484. Traces of a variety of other substances have been discovered. In various specimens of different kinds of animal blood, are other animal acids, already described, and Fluorine, Silicon, Manganese, Lead, and Copper; all however in combination.

The composition of blood varies greatly among different animals; in health, disease, &c.: the percentage just given refers to healthy human blood.

Blood has an *alkaline reaction*. Its composition may be stated generally as water, containing salts and gas; red globules con-

Sources of Fibrin?

480. What are mentioned as consisting of Gelatin?

481. Water and *blood*? What are dissolved? What salts in the blood, and what per cent.? *Fresh arterial blood*?

482. Description and size of the *red globules*? [How much coloring matter and what is it called? What forms the remainder of the globules? What per cent. of the blood is globules?

483. State the percentage of Albumin, Fibrin, and Fats?

484. What other substances are traced in the blood of various animals? Variation? Percentage?]

Reaction of blood? Its general composition?

sisting of Hematosin, Iron, and Protein; Albumin; Fibrin; several different fats; and traces of other matters.

485. MILK. This liquid also varies exceedingly, but good cow's milk is more than eighty-seven per cent. *water*; about three per cent. butter; about five per cent. Casein, with some Albumin; over four per cent. Lactose (444); and about one half per cent. salts which are mostly Chlorids, Fluorids, and Phosphates, of which the metals are Potassium, Sodium, Calcium, Magnesium, and Iron. Human milk is richer in Lactose, and contains less Casein.

486. THE FLESH FLUID. This substance is four fifths of fresh muscle, and abounds in an Albuminous Protein, Creatin (446), Inosinic acid (458), and salts of Potassium and Sodium, more especially the latter, and being chiefly Phosphates and Chlorids.

487. THE SALIVA AND PANCREATIC JUICE, are quite similar in composition, both having an *alkaline reaction* and containing Pepsin (447), and alkaline Phosphates, and Chlorids. The *saliva* contains a salt of Sulphocyanic acid (460) and is frothy, with much Oxygen dissolved.

488. THE GASTRIC JUICE. This substance contains *free Lactic acid* (452), *Pepsin*, and *Salts*.

Its reaction is acid. Its effects on the food will be considered under the head of *Digestion* and *Nutrition*.

489. THE BILE. This fluid originates from the action of the *liver* on *venous blood*; it has highly characteristic properties.

Normal human bile is a greenish, viscid, translucent liquid. It has a disagreeable odor and taste, and is *intensely* bitter. Its taste and odor are due to the *Cholate* and *Cholate of Soda*, containing *Cholic acid* (457), which consists of the four organic elements, and also *Choleic acid* (460), which contains Sulphur.

Beside these, there are present Chlolesterin (469), coloring matter, Chlorids, and Phosphates. *Bile has an alkaline reaction*.

490. THE CHYLE is very similar to blood in composition, but contains no red globules, and very little Fibrin. It is a white creamy liquid, abounding in Albuminous and fatty matter, and salts.

491. THE URINE. In different animals there is considerable variation in this product of the *kidneys*. Uric (455), Hippuric (456), Benzoic (453), and Phosphoric acids and salts are found; and Ammonia, Urea (449), Creatin (446), and Creatinin (446). The most *characteristic substances, however, are Urea and Uric acid*.

The *solid exuviae of animals*, contain undigested and indigestible matters, and abound in Phosphates and other salts.

492. The *Brain and Nerves* are about four fifths water and con-

485. State the different elements of milk and their percentage?

[486. Particulars in reference to *flesh fluid*? 487. Saliva and pancreatic juice?]

488. Gastric juice? Its reaction?

[489. 490. 491. Particulars of *bile*, etc. ?]

492. Composition of *brain and nerves*?

tain Protein substances, Chloresterin, Cerebric acid (459), and Phosphorus.

Horns, hoofs, and hair, are similar to each other in constitution, consisting of C, H, N, O, and S. The horns of the deer are more like bone. Tusks and teeth are highly compacted bone.

493. Eggs vary somewhat in composition; but Albumin is their most characteristic and abundant constituent. Fat, Phosphoric acid, Lactic acid, and salts, are also present.

It will be now in order to consider

DIGESTION AND NUTRITION.

494. *Digestion* is mostly a Mechanical and Chemical process: it is intimately related to Nutrition which is more of a Physiological character.

495. *Mastication and insalivation* the first processes of digestion, are performed in the mouth. They *should consist*, in a thorough subdivision of the food as far as possible, and a complete admixture of it with the fluid poured out by the *salivary glands*.

By this means, the first stages of digestion will be properly instituted, and the Starch of the food, will begin, by the agency of the Pepsin, to be transformed into Glucose, and converted into a soluble state. The oily and fatty portions of the food, by means of the free alkalis, will also begin to be dissolved; since, as will be hereafter shown more particularly, but as is generally well known, alkalis convert Oils and Fats, which are insoluble in water, to soaps which are readily soluble.

These two processes, (which are still further favored by the saline properties, and the free O. of the saliva,) completed, the masticated and insalivated food suffers

496. *Deglutition*, a merely mechanical operation in which it is *swallowed*; that is, it passes through the *esophagus* or *gullet* and through the *cardiac orifice* into the stomach, to undergo a new process,

Chymification. Here are substances, such as Lactic acid, which are capable of dissolving flesh.

The contents of the stomach are kept constantly in motion; being rolled about and thoroughly mingled with the *gastric juice*; the free acid of which and the Pepsin and salts, are

Horns, hoofs, hair, teeth, etc.?

493. Composition of eggs? What subject follows?

494. Nature of *digestion*? Nutrition?

495. Give an account of *mastication* and *insalivation*?

496. Deglutition and Chymification?

powerful chemical solvents; and by these means the food is reduced to a sort of pulp, called *Chyme*.

497. The *Chyme*, passes gradually out of the *pyloric* opening of the stomach into the *duodenum* or first portion of the intestine and here undergoes

Chylification. This process is the result of the action of the *bile* and the *pancreatic juice*, which are here poured into the *chyme*.

By the action of the various chemical agents which these fluids contain, as, by their alkali and fats, and their mineral and organic salts, and Pepsin,—the digestible substances of the food, if not in excess, are finally thoroughly modified and dissolved. The processes begun in the mouth are here finished, and the *chyme* becomes *chyle*.

498. The *chyle* is then taken up as required, by the *lacteals*, which are small vessels thickly distributed to the *duodenum*, and passing through these and the glands which they form, is gradually modified by the way, and is transmitted from them into the *thoracic duct*.

This is a single small tube passing from the abdomen up into the *thorax* or chest, where it opens into the *left subclavian vein*.

As the *chyle* rises through the *thoracic duct*, it is more and more modified, approaching nearer to the composition and properties of blood; and finally, when it leaves this duct and enters the vein, it is soon brought into contact with the general mass of the circulating fluid; it goes to the heart and the lungs; and the last process of digestion is finished: that is, it has become blood and has undergone *Sanguification*.

499. In the mouth, stomach, and intestine, the process is mostly mechanical and chemical: that is, the food is mechanically and finely divided; and is then subjected to simple and chemical solution; while the final portion of the process of digestion, is the result of the action of vital forces, by which the material is gradually organized into blood and partakes of all the properties of that fluid.

500. The *Nutrition of the animal system* is a process of assimilation and transformation. The materials for the construc-

497. Into what does the *chyme* pass, going from the stomach? What does the *chymified* food undergo in the *duodenum*? What fluids are here mingled with it? What chemical agents here act and what is their effects?

498. What next becomes of the *chyle*? What are the *lacteals*, and to what distributed? Course and modification of the *chyle*? Into what does the *chyle* go? *Thoracic duct*? It opens into what? What finally becomes of the *chyle*? What is its last change called?

499. What is the digestive process at first? Finally?

500. What sort of a process is *nutrition*?

tion of flesh and of the solid portion of bone, exist already formed in the blood, and are assimilated unchanged. No other than a Protein substance is found capable of becoming flesh.

The Gelatin required for the construction of other tissues, and the matter for the production of all the peculiar animal principles, are transformed from the Protein compounds, or from the other elements of food, as Starch, Gum, Sugars, and fats.

501. It is the blood, which, containing all necessary material, supplies every part of the system with that which is suited to its wants. It moves to every point, furnishes material for bone, for muscle, and ligament and tendon; receiving at the same time all the waste matter, not exhaled from the skin, and carrying it where it can be ejected from the system, if no longer required.

The animal body is a complete laboratory, where mechanical, chemical, and vital forces are continually in operation, and in which there is a constant, and ever necessary change.

502. *Waste and Supply.* Every motion of an organ or part of an organ results in a waste of tissue. The exercise of a muscle is attended by the destruction of some of its parts; but if the exercise is judicious, it is connected with an incitement, by which the muscular part is not merely renewed, but is strengthened and increased.

The animal is constantly receiving accessions of material, some portion of which is as constantly being assimilated; and since its own weight remains, in many cases, unchanged, it must be throwing off a quantity of matter equal to what it receives.

Another cause of waste, besides that resulting from the action of the muscles, is seen in

503. *The Process of Respiration.* In this process, the Oxygen of the air acts upon the dark colored venous blood in the lungs, and suddenly gives it a bright red hue; this effect is produced by O. on venous blood even out of the body.

The blood having largely absorbed O. in the lungs, passes to the heart, by which it is propelled through the arteries to the

What are *assimilated* unchanged? What are transformed? What supplies every part and how?

501. What other office of the blood is mentioned? What is said of the animal body?

502. Effect of the motion of an organ? Of judicious exercises? Accessions of matter to the animal, assimilation, and waste? What other cause of waste, beside motion, is mentioned?

503. Effect of O. on venous blood, in and out of the body? What does the blood absorb from the lungs? Course of the blood, and name of the vessels carrying it from the heart?

extremities, carrying the O. along with it. The arteries extending from the heart continually branch or subdivide, becoming at last extremely minute, where they are called *capillaries*.

504. From these, mostly, it is that the blood yields to the proper organs, whatever is required; and taking up, on the other hand, what is not, it returns again toward the heart. Its free O. has, however, disappeared; and it is charged instead with Carbonic acid.

Coming back to the heart, it is sent by that organ to the lungs, to give off its Carbonic acid with some water in vapor, and again to receive O.

505. Thus O. is continually absorbed into the system in a free state, and as continually given out again, combined with C. and H. in the form of water and Carbonic acid. The result is the same as if C. and H. had been burned; not merely in respect to the production of Carbonic acid and water; but, also, since there has been a chemical combination (353), in respect to the production of heat.

The origin of animal heat is, in this way, then, accounted for.

506. But this process of respiration is constantly withdrawing C. and H. from the system, and converting them into substances which pass off into the air. It is a wasting process to the system, and must be supplied from some source.

The source of supply of C. and H. for respiration, is, first, the ternary elements of food,—the Starch, Sugars, Fats, and Gum. In the absence of these, as occurs with some animals, there must be a decomposition of Quaternary substances; and, most likely, not those of the food, but of the flesh of the animal.

In case of starvation, the flesh is consumed to maintain the process of respiration, and the muscles gradually waste away.

507. In the decomposition of flesh, whether for the production of motion by the contraction of the muscles, or for respiration; while C. and H. pass into the air as Carbonic acid and H₂O. Nitrogen and Phosphorus appear, in the fluid and solid exuviae, in the shape of Urea and its modifications, and in Phosphates.

Branching of the arteries, and name of their smallest branches?

504. What does the blood yield and take up in the capillaries? What replaces the O? To what does the blood return? Where then sent, and for what purpose?

505. Absorption and change of O? What is said of the result, and why?

506. How is respiration a wasting process? What is the first source of supply for respiration? What, when ternary substances are not present in food? Starvation?

507. The N. and P. when flesh is decomposed?

Even the brain seems to be subject to the same exhaustion by exercise, and thus to suffer waste and supply.

508. *Formation and deposit of Fat.* Where the animal receives a quantity of ternary substances into the system, greater than can be removed by respiration, there is a conversion of the Starch, &c., into fat which is deposited in the tissues.

On the other hand, when the supply of these ternary substances is inadequate, any fat stored in the system is taken up and consumed, to maintain respiration.

Examples of this are seen, in *hibernating* animals, which fatten in autumn, lie close and take little food in winter, and in the spring appear with their fat exhausted.

509. It has been seen that the food of animals is of two kinds: 1st, Starch, Sugars, Gums, and Fats, which are the *elements of Respiration*; and, 2d, Protein substances: Fibrin, Albumin, Legumin, &c., the *elements of nutrition*, which go to form the tissues.

510. *Opposing action of Plants and Animals.* Plants draw their nourishment from the mineral kingdom; they take water, Carbonic acid, Ammonia, and Salts; and, liberating O. into the atmosphere, convert them into organic substances, which become the food of animals.

These organic substances are consumed by animals. They take up O. from the air, and give out, as mineral substances, Carbonic acid, water, Ammonia, Urea compounds which are converted into Ammonia, and Salts.

Here, then, is seen, "on the other hand," the link of connection between plants and animals, before referred to (391). Carbonic acid, water, Ammonia, and salts, are the substances which animals throw out into the mineral world; these, also, are the substances which plants require.

The organic Protein substances, and neutral Ternaries, pass from plants to animals, and form the connection on one side; the mineral compounds, Ammonia, Carbonic acid, and water, pass from animals to plants, and are the connection on the other. The elements of these two classes of connecting substances are continually moving in a circuit in the organic world.

The brain?

508. How may fat accumulate? In what case is the fat of the system consumed? Example?

509. Two classes of animal food, objects of each and examples?

510. What mineral substances do plants take up, what do they liberate into the air, and what do they form? What do animals consume, what withdraw from the air, and what mineral substances do they yield? What substances pass from plants to animals, and what from animals to plants? Circuit in which certain elements move?

Having now considered the most important chemical relations of living *plants* and animals, it will be requisite to next attend to

THE NATURAL CHANGES

in organic bodies

AFTER LIFE.

511. These changes come under the heads of *Eremacausis*, *Putrefaction*, and *Fermentation*.

EREMACAUSIS, from the Greek *erema*, by degrees, and *kausis*, burning, may be applied to the slow decay which bodies suffer by natural means. An example is seen in the gradual wasting of wood and vegetable matters. Ternary substances under the influence of a moderate degree of moisture are generally subject at common temperatures to this slow decay.

512. PUTREFACTION is properly applied only to the rapid decomposition which may occur in Quaternary substances, or in bodies containing them. Animal, and certain vegetable substances, such as flesh, eggs, cheese, and the paste, or the washing of wheat flour, may putrefy.

The term *putrid*, is commonly applied to a state of decomposition in which a strongly disagreeable scent arises. This odor is due to such substances as Ammonia, Sulphuretted Hydrogen, and Phosphuretted Hydrogen; or substances arising from new combinations of Nitrogen, Sulphur, and Phosphorus.

It is only the quaternary substances that contain N. This N. and very small quantities of S. and P. present in the quaternaries then produce the odor.

513. *Putrefaction only goes on* within certain ranges of temperature. It can not occur at, nor below, the freezing point, nor above 192°.

Moisture is also generally necessary. In regions where the air is unusually dry, flesh, and even the bodies of animals, remain unaffected, and are indefinitely preserved.

514. Common salt and Alcohol are effective in preventing decay, because they strongly attract water, and thus, in effect, *dry* the substance. This is seen in the preservation of animal

Subject following that of the relations of living plants and animals?

511. Under what heads do the natural changes come? What is *Eremacausis*? Example?

512. Putrefaction? In what does it occur? Examples? The term *putrid*?

513. Effect of temperature on putrefaction? Moisture?

514. Action of salt and Alcohol? Examples?

matter by means of common salt, as with salted meat; and specimens of animals and anatomical preparations preserved in Alcohol. Alcohol also acts, by coagulating Albumin, and rendering it insoluble, and incapable of being affected by water. Such substances as corrosive sublimate, Sulphate of Iron, Tannic acid, Creasote, are also *antiseptic* or have a similar effect on organic substances; and are used on this account.

515. A putrescent substance is capable of communicating its own condition to other bodies; and hence causes putrefaction, in those that have a quaternary composition.

It is well known that a putrefying substance, introduced into the blood, even in small quantity by a slight incision, as sometimes occurs in dissection, may communicate such a disorganizing influence to the system, as to cause death. The same kind of influence is supposed to explain the communication of disease by infection: the infecting matter being thought to be absorbed into the system in some way, where it institutes disorganizing influences.

516. Putrescent bodies act as *ferments*, and impart a much more rapid change, than that of ordinary decay, to *Ternary substances*, in the course of which peculiar compounds are formed.

FERMENTATION.

517. This term is applied to different kinds of peculiar decomposition in ternary substances, instituted originally by a quaternary substance, which is itself in the act of putrefaction, or in a certain state of change.

There are several kinds of fermentation, each taking its name from the peculiar substance which it produces as the *Alcoholic*, the *Acetous*, and the *Lactic acid*, or *Lactous* fermentations. The first consists in the conversion of Grape Sugar into Alcohol and Carbonic acid; but before it is especially noticed, the *ferments* require further attention.

518. Beside the Protein substances, blood and Gelatin, all of which being putrefiable, may act as *ferments*, there are certain special ferments such as *yeast* and *diastase*.

Another cause for the action of Alcohol? Other agents that render organic substances insoluble?

515. Action of a putrescent body on quaternary substances? On the blood and examples? Infection?

516. Ferments? Class of substances on which they act? What are formed?

517. What is fermentation? Kinds of fermentation and names? The Alcoholic?

518. What are mentioned as ferments? What special ferments?

YEAST. This is the decomposing Protein substance that is present in a fermenting mass. When separated, washed, and dried, it is a grayish yellow powder, destitute of taste and smell, and scarcely soluble in water. Its composition is variable. In fermentation, there is generally a sort of fungous plant observed in connection with it which has been supposed, probably erroneously, to exert some influence.

Yeast has the property of causing a transformation of Cane Sugar into Glucose, and of inducing in this latter Sugar the Alcoholic fermentation.

When fermentation occurs in any mass containing a portion of Protein, the quantity of yeast increases; being derived from the Protein: but where yeast is introduced into a solution of pure Sugar, it wastes away, from its own decomposition.

519. **DIASTASE** is of a character very similar to yeast. It appears to be merely a Protein substance in an earlier stage of decomposition, than yeast. It has the power of converting Starch into *Dextrin* and from that into Grape Sugar. *Dextrin* is merely a soluble modification of Starch having properties similar to Gum. *Malt* is barley that has been soaked in water until *germinated* or sprouted, and has then been dried. From malt diastase is obtained by a simple process. It is capable of converting 2000 parts of Starch into Grape Sugar.

THE ALCOHOLIC FERMENTATION.

520. This fermentation, sometimes called the *vinous* fermentation, since it occurs in wine, Lat. *vinum*, has been defined to consist in the transformation of Grape Sugar into Alcohol, $C_4H_6O_2$, and Carbonic acid, CO_2 .

Since the formula of Grape Sugar is $C_{24}H_{44}O_{24}$, it contains the elements of four equivalents of Alcohol $4C_4H_6O_2$, and eight of acid, $8CO_2$. This is the actual result of the fermentation of this Sugar.

The Alcoholic fermentation may occur under a variety of circumstances. It is always Glucose that undergoes this fermentation. Cane Sugar furnishes Alcohol by being first converted into Glucose.

What is yeast? Fungous plant? Property of yeast? Increase and waste of yeast?

519. Diastase? Power? Dextrin? Malt? From what may diastase be obtained? Effects on Starch?

520. Other name for the Alcoholic fermentation and why? Definition? Explain the results of the decomposition of an atom of Glucose? From what is Alcohol always produced in fermentation? Into what is Cane sugar converted before the vinous fermentation occurs?

521. A solution of pure Sugar does not undergo fermentation; but the addition of yeast, or other ferment, will produce this decomposition.

The sweet juices of stalks and fruits, always containing Albumin, will spontaneously ferment by exposure at common temperatures to air, by which the Albumin begins a decomposition, that converts it into a ferment.

522. *The rising of bread*, is a result of the alcoholic fermentation. By the use of yeast, the fermentation occurs in the *sponge*, and is continued after the kneadings.

This fermentation produces Carbonic acid gas which, in minute bubbles, is retained by the toughness of the dough. These bubbles constantly evolved, cause the dough loaves to swell to something like twice their original size, before the loaves are baked.

The fermentation of the dough originates with the Sugar contained in the flour, and ceases when that is exhausted.

If, in bread making, the dough loaves are baked too soon, they will not be sufficiently light, for the fermentation is entirely arrested by the heat of the oven. By leaving the loaves too long, before baking, the fermentation passes on to the formation of Acetic and Lactic acids, and the bread becomes sour; this is best amended by the use of a little Bicarbonate of Soda.

Much depends on the good quality of the yeast, which must be fresh and sweet. Sour yeast gives rise to acids in fermentation, and yeast that has too far decomposed is less active. Brewers' yeast, which is that body rising to the surface in the fermenting vessels at the breweries, is an active and excellent yeast if fresh. The good housewife herself prepares new yeast, before the old has become impaired, and thus always has fresh.

523. The effect of the usual process in bread making, is, to convert most of the natural Sugar of the flour into Alcohol and Carbonic acid, both of which disappear: to convert about $\frac{1}{4}$ of the original Starch into the soluble form, and a part of this into Sugar; and to diminish, somewhat, the natural toughness of the Glutin, by incipient decomposition and baking, and thus increase its digestibility: some portion of the Albumin of the flour must enter into decomposition, thus adding force to the fermentation instituted by the yeast.

521. Pure sugar how fermented? Origin of fermentation in juices?

522. Cause of the rising of bread? How? The fermentation of bread is confined to what substance? Baking loaves too soon or too late? Good yeast in bread making?

523. Effect of the bread-making process?

524. All fermented liquors necessarily contain Alcohol as a product of the fermentation.

The Alcoholic fermentation of different juices and sweet solutions and the subsequent distillation, gives rise to all the variety in Alcoholic beverages, the peculiar flavor of which arises from the characteristic *ether* present. Latterly many of these drinks are *fictitious*, or made directly from an Alcohol of greater or less purity by the addition of a variety of substances often more poisonous than the Alcohol itself.

525. In a liquid mass, the Alcoholic fermentation proceeds best at a temperature between 68° and 77° .

If milk is kept at a temperature of 100° , its Casein institutes the Alcoholic fermentation. Alcohol will be described in its proper place.

THE ACETOUS FERMENTATION.

526. This gives rise to Acetic acid, $C_2H_4O_2$, hereafter to be noticed. It occurs possibly in two ways. 1st: As has been mentioned, it follows the Alcoholic fermentation when that is allowed to go so far, and under certain circumstances may perhaps go on contemporaneously with that decomposition.

The Acetous fermentation occurs in weak Alcoholic solutions by exposure to air. The change of Alcohol, $C_4H_6O_2$, to Acetic acid is very simple; for, by absorbing O_4 from the air, Alcohol furnishes Acetic acid, $C_2H_4O_2$, and 2 eq. of Water, $2H_2O$.

2d. The long action of cheese curd, on a solution of Sugar at 68° , converts it to Acetic acid; the change being apparently, the formation of just $6C_2H_4O_2$ from Glucose, $C_6H_{12}O_6$.

527. The *Lactous fermentation*, by which Milk sours, is an extremely simple change; since an equivalent of Milk Sugar, with as much water as it is combined with in crystalization, is $C_{12}H_{22}O_{11}$, and just furnishes two equivalents of Lactic acid, $C_3H_5O_3$.

This Lactous fermentation may be excited and continued in a solution of Sugar, by the action of curd, at a temperature of

524. Constitution of fermented liquors? Cause of the peculiar flavor of Alcoholic beverages? Nature of those now manufactured?

525. Temperature most favorable to fermentation in liquids? Alcohol from milk? What fermentation is next described?

526. What is produced in the Acetous fermentation, and symb.? Connection of the Acetous and Alcoholic fermentations? Explain the change of Alcohol to Acetic acid and give the symbol? The production of Acetic acid from sugar, by means of cheese curd?

527. The chemical changes in the souring of Milk (on the blackboard)? Lactous fermentation in sugar by curd and temperature of 80° , etc.?

80° to 95°, if some chalk is present, to neutralize the acid as fast as formed.

528. *It is often desirable to prevent fermentation*, in order to preserve fruits, and vegetable substances containing Starch and Sugar in a moist state. This can be effected in various ways: as; if the articles are fresh, by the exclusion of air, since it is the O. of the air that, assisted by a certain temperature and moisture, institutes the putrefaction of the Albumin and thus forms a ferment: also by a constant temperature at 32°, or below, or at 192° or above.

Fermentation may be arrested when once instituted by means of heat, or cold, or chemical deoxydizing agents, as Sulphurous acid.

529. In respect to the nature of the decomposition in fermentation, it has been observed, that it consists in the breaking up of a compound into *several* substances which have a more simple constitution. The acetous fermentation from Grape Sugar produces merely *several equivalents of one and the same* substance.

Other less important fermentations will be noticed in connection with the description of their products.

We may notice, next the other

CHIEF PRODUCTS OF NATURAL DECOMPOSITIONS.

530. *Vegetable mould* is the result of a slow decay of vegetable bodies, in which Water, Carbonic acid, Ammonia, Sulphydric acid, Nitric acid, Phosphuretted Hydrogen, and Carbo-Hydrogens, are produced.

Humus, geine, etc., are variable substances that have been described as resulting from this decomposition.

Asphaltum, pétroleum, Naptha, and *bituminous coal*, are bituminous substances that have resulted, in all probability, from the action of natural forces on ancient vegetable matters buried in the earth.

531. *Naptha*, $C_{12}H_{10}$, is a colorless oil, often called *mineral Naptha*, and having apparently a definite composition. It is a very abundant natural substance, and sometimes nearly pure. It is used to preserve K. and Na, and in medicine.

Asphaltum is a solid bitumen, and *pétroleum* (Lat. *petra*, a rock, *oleum*, oil), a dark colored tarry liquid. These and other bitumens are of variable composition and highly combustible. *Pétroleum* having been collected by the Seneca Indians, has received the name of *Seneca oil*; it contains *Naptha*.

532. *Paraffin*, $C_{18}H_{50}$, is a substance forming slender white crystals; and contained in *pétroleum*. It is also extracted from coal tar; and is produced by the action of heat upon wax. It fuses at 110° and dissolves in Alcohol and Ether.

528. Why desirable to *prevent* fermentation? How? How *arrested*?

[529. Nature of the decomposition in fermentation?] Other fermentations? Next subject?

530. Origin of vegetable mould, and other products? *Humus* and *geine*? What bituminous substances are mentioned and their origin? 531. *Naptha*? *Asphaltum*? *Pétroleum*? *Seneca oil*? 532. *Paraffin*, symb., source, and properties?

Peat, lignite, anthracite, and *graphite*, are all carbonaceous bodies, that have resulted from the action of natural forces upon a former vegetation. *Anthracite* has, apparently, been subjected to a very high temperature, and *graphite* to a still more intense heat. *Lignite* exhibits, perfectly, the woody structure which is discoverable even in *anthracite*. *Peat* is a swampy vegetable deposit, and has resulted partly from the action of water.

533. There are many other substances which are of similar origin, but except such as may come into notice hereafter, only two more can be described.

Among the most interesting results of natural action upon substances, originally organic, are the two gaseous compounds of Carbon and Hydrogen. These may be denominated *Formen* and *Etheren*.

534. FORMEN, C_2H_4 , = 16. *Dens.* 55. This gas has generally been denominated *light* Carburetted Hydrogen, and also *marsh gas*. It results from the decomposition of vegetable matter covered with water: and may be collected in many a stagnant pool by stirring the mud at the bottom, and catching the bubbles of gas as they rise.

It may be produced artificially from Acetate of Potassa, $C_4(H_3K)O_4$, by the action of Hydrate of Potassa, KO, HO , and heat; some Lime being used to preserve the flask from the action of the Potassa, at the high temperature required.

2 Equivalents of Carbonate of Potassa, and one of the gas result, thus: $C_4(H_3K)O_4 + KO, HO = 2(KO, CO_2) + C_2H_4$.

535. This is a colorless, inodorous, slightly soluble, and combustible gas; burning with a yellowish blue flame and producing water and Carbonic acid. With two volumes of O. it explodes violently. By the action of Cl, moisture, and light it is converted into Carbonic and Chlorohydric acids. It will be necessary to refer to it again.

III. 469. Production of C_2H_4 .

III. 470. Its combustion and explosion.

536. ETHEREN, C_4H_4 , = 28; *Dens.* 94. This gas is best known as *heavy* Carburetted Hydrogen, and also as *olefant* gas. It is colorless, but has considerable odor, and is somewhat soluble in water. It burns with a rich yellow light, and mixed with three volumes of O. explodes, on the application of flame, with very great force.

Formen and Etheren abound in bituminous coal mines; and

[Other Carbonaceous bodies and their origin? Heat, anthracite, and graphite? Lignite? Peat? 533. Other substances resulting from natural influences? Formen and Etheren?

534. Symb., equiv., and dens., of Formen? Other names? Sources? Artificial production? Lime? [Changes?]

535. Properties and Results of its Combustion? Explosion? Chlorine? Production, 469? 470? 536. Symb., Equiv., and Dens. of Etheren? Names? Properties? Combustion? Sources of Formen and Etheren?

mixed with air, form the dangerous explosive mixture, called by the miners *fire damp*.

537. The explosion of such mixtures, in the mines, have destroyed thousands of lives.

The well known miner's "safety lamp," the invention of Sir Humphrey Davy, consists of a lamp for burning oil; and with an enclosure of wire gauze around the flame.

Its action depends on the fact, that while the mass of gas forming a flame can readily pass through a fine wire gauze; yet, in passing through, it is so much cooled, by the conducting power of the wire, as to be no longer incandescent, nor capable of firing an explosive mixture.

When in use in the mine, in the presence of the combustible gas, the flame of the lamp enlarges, by the passage of the gas through, to the inside of the gauze; but no explosion occurs; while the enlargement of the flame is a warning of the danger, and shows the necessity for a better ventilation.

538. Carburetted Hydrogen* gas issues abundantly from the earth in many localities. The village of Fredonia, Chautauque county, New York, is lighted with the natural gas; and on the Kenawha river, Va., the salt brine is evaporated, by means of its combustion, from natural sources.

The great practical importance of Carburetted Hydrogen gas for artificial illumination, will exact some further attention to these two substances; but, before this can be given, it will be necessary to introduce the final division of substances to be described. This embraces

ARTIFICIAL ORGANIC PRODUCTS.

539. The substances now to be noticed, are those that are more commonly the result of transformations of organic products by artificial means. The two gases, C_2H_4 and C_4H_4 , may well serve to introduce this extensive class of substances; for both are comparatively large products, naturally and artificially.

* This term is used here and hereafter to denote a variable and impure mixture of Formen and Ethern.

Fire damp? 537. Explosions in mines? Davy's lamp? Principle of its action? Action of the lamp in the mine? 538. Other sources? Use of the term Carburetted Hydrogen? Fredonia? Kenawha? Importance? Final division of organic substances? 539. Sources of the substances of this division? What two gases connect the natural substances with the artificial, and why?

In the latter case they are known, in an impure condition in the large way, as

COAL GAS.

540. *Coal gas* is generally employed for the illumination of all considerable towns in the United States.

The material from which it is produced, is bituminous coal, which is heated to a bright red heat in peculiarly shaped Iron retorts.

541. The products are various; but are principally, Formen, Etheren, Hydrogen, volatile Carbo-Hydrogen oils, Ammonia, Carbonic Oxyd, Carbonic acid, Sulphydric acid, coal tar, coal oil, Sulphurous acid, Nitrogen, and Cyanogen; but several of the latter in quite small quantity. The volatile Carbo-Hydrogens, and Formen, and Etheren, are the only valuable products, the last, having, except the oils, much the highest illuminating power. None but these and H. with the slight trace of N. and Carbonic oxyd, should be allowed to go beyond the gas works. All the others, as well as some of these, impair the general illuminating power below that of the Carburetted Hydrogens, beside diffusing offensive odors. The others are arrested by washing the product through water; by cooling; and by the action of fresh and nearly dry Hydrate of Lime.

542. The gas thus produced, when properly burned, is the best, safest, and cheapest known light.

As to the ratio of Coal to gas, it is found that one hundred pounds of good coal furnish about four hundred cubic feet of gas, leaving nearly two thirds of the coal in the retort, as *Coke*, a portion of which will be sufficient to expel the gas from one hundred pounds of coal. Beside the gas, some other of the products are valuable. The coal oil is used as a solvent for Caoutchouc; the compounds of Ammonia are prepared from the coal gas product; and *Prussian blue* is manufactured from the Cyanogen compound.

543. The cause of the brilliancy of the Carburetted Hydrogen flame lies in the quantity of C, which it contains, as already explained (81). The products of the complete combustion of the Carbo-Hydrogens are water and CO_2 .

Like the mixed substances forming it, Coal gas is powerfully explosive when properly mingled with air; and serious accidents occasionally occur, through ignorance or carelessness in entering places with a light, into which it has leaked and mixed with the air to form an explosive mixture.

III. 471. Coal gas evolved by a high heat from bituminous Coal in the bowl of a tobacco pipe, covered with a layer of clay; and burned as it issues from the stem.

Large production artificially? 540. Use of *coal gas*? Source of coal gas? [541. Products in its manufacture; which valuable; which to be arrested and how?] 542. Value for light? [Ratio of gas to Coal? *Coke*? Other valuable products and their use?] 543. Brilliancy of the flame? Danger? Production of coal gas, 471?

Ill. 472. Appearance and physical properties of Coal gas.

Ill. 473. The gas burns with a fine yellow light.

Ill. 474. An upright jar full of the gas, being set on fire, water is poured on the flame, but passing through into the jar, produces no other effect than to push the flame aside and to lift the gas up into the air.

Ill. 475. The gas being thrown on Davy's Lamp, takes fire inside the gauze only.

Ill. 476. A mixture of Cl. and coal gas, made and quickly fired, results in a large deposit of C.

Ill. 477. A balloon of *Gold-beater skin*, if not much less than two feet in diameter, filled with Coal gas, rises like one filled with pure II.

544. Coal gas is almost universally employed for the inflation, in balloon ascensions. While heavier than H. it is much less liable to escape. The diffusive tendency of II. is so great that where it is to be used the balloon must be made of the best material. The *Sp. gr.* of coal gas varies with the quality of the coal and the details of the process, but ought to be as high as .659. It is sometimes no more than .4.

Ill. 478. A mixture of coal gas and $2\frac{1}{4}$ vols. of O. explodes with great force.

545. Etheren may be obtained nearly pure by the action of Sulphuric acid and heat upon Alcohol: there being three volumes of HO,SO₃ to one of Alcohol.

To separate the Sulphurous acid, Carbonic acid, and Ether, which are also developed in this process, the gas may be washed through solution of Potassa, and also through Sulphuric acid; but this purification is unnecessary for illustrative purposes, as, when collected over water in the usual way, the impurities are sufficiently separated.

All the operations performed with coal gas may be reproduced, with Etheren from Alcohol; but, with still better effect, on account of the superior quality of the gas.

546. By mixing equal volumes of Etheren and Chlorine, they combine and produce a heavy sweetish oil. The discovery of this fact gave the name, *olefiant* or *oil-forming* gas to Etheren. The oily compound is C₄H₄Cl₂, and is called *Bichloric Etherilen*.

Ill. 479. Violent explosion of C₄H₄, with three volumes of O.

Ill. 480. A fine Iron wire burns in a small jet of C₄H₄ like steel in O.*

Ill. 481. Formation of Bichloric Etherilen.

547. EFFECT OF HEAT ON WOOD. When wood is circumstanced similarly to coal in the production of coal gas, or is powerfully heated, being enclosed from the air, it yields somewhat similar products: illuminating gas, Ammonia, etc. Some towns are lighted in this way, but more commonly, the direct object of the process, which is termed the "*destructive distillation*"

* Is this new?

Properties, 472? Light, 473? Water on flame, 474? Davy's Lamp, 475? Cl, 476? Balloon, 477? 544. Gas for inflation of balloons, and why? Coal gas and O. 478? 545. Etheren from Alcohol? [Separation of other products? Operations with Etheren? 546. C₄H₄ and Cl? Olefiant gas? Name for C₄H₄Cl₂?] C₄H₄ and O? And Fe? 481? 547. Subject? Products of heating wood powerfully without access of air? Towns lighted? Most common objects of the process? Name of process?

of wood, is either the production of impure Acetic acid, known as *pyroligneous acid*; or else it is for the purpose of obtaining *wood-tar*.

As to the formation of coal gas, the products are numerous; one or two may here be noticed.

548. KREASOTE, $C_{12}H_{10}O_2$. This is a combustible, poisonous oil, having a powerful odor of smoke, and slightly soluble in water. It is highly *antiseptic* from its coagulating power on Albumin and Gelatin, so that meat, immersed in a solution of it for a few minutes, will not putrefy. Hence the name from *kreas* flesh, *sozo* I preserve. It is the active agent in preparing "smoked" meat. It forms crystalline compounds with the alkalis.

III. 482. Specimen, odor, and combustibility of Kreasote.

Some other of the results of the action of heat on coal and wood come under the head of

SOLID AND LIQUID HYDRO-CARBONS.

549. These substances are numerous; one of them,

EUPION, C_8H_8 , is found in the tar from the destructive distillation of animal and vegetable matters. It is a thin, colorless, aromatic, liquid, sp. gr. .665.

NAPHTHALEN, $C_{10}H_8$, is prepared from coal tar. It forms beautiful and fragrant crystals.

550. Leaving these substances, which are highly interesting, we may now enter upon some classes of substances of very remarkable composition.

For example, the first class which will be noticed, is the class of Alcohols; and these, though differing in composition, may all be represented by the same symbol, merely by employing a literal, instead of a numeral multiplier as heretofore, and allowing to this letter a variable value, yet restricted within certain limits. This class of Alcohols may be represented by the symbol $C_nH_{n+2}O$, the letter *n* representing the same number for any one Alcohol; whether attached to the O. or the H; and in all cases, it represents a number divisible by two. All the bodies which may thus be represented by the same formula are said to be *homologous* with one another.

THE ALCOHOLS, $C_nH_{n+2}O_2$.

551. These substances are so named and classed since their composition is homologous, with that of common Alcohol, $C_4H_{10}O_2$. The first of the series is

Number of products? 548. Symb. of Kreasote? Properties? Why antiseptic? Meat? Name? Compounds? Specimen Kreasote, 482? Head for other products? [549. Number of Hydro-Carbons? Symb., source, and properties, of Eupion? Of Naphtalen?] 550. The classes next noticed are remarkable, how? First class? In what way, may they all have one formula? Formula for all the Alcohols? What is indicated by the letter *n*? Term applied to those substances which may thus have one formula? 551. Why are certain substances called *Alcohols*?

552. METHOL, $C_2H_4O_2$. This is a product of the destructive distillation of wood, and has received several other names, as *pyroxytic spirit*, and *wood naphtha*, names which indicate its origin. But the name first given from *methu*, wine, and *auton*, wood, is short and appropriate. Methol is a colorless, pungent, volatile, liquid; burning with a pale blue flame. It is used in medicine.

Ill. 482, a. Specimen and properties of $C_2H_4O_2$.

553. VINOL, $C_4H_6O_2=46$, *Dens.* .8, is common Alcohol, the source of which has been described under the head of *Alcoholic fermentation*. It is well known in its ordinary commercial form, in which, however, it is not entirely pure, being usually when strongest, about 93 or 94 per cent. pure Alcohol,—the remainder being water. Pure Alcohol, called, generally *absolute* Alcohol, is produced by the action of Chlorid of Calcium on the commercial article, and subsequent distillation.

Alcohol is separated from the fermented liquor in which it is formed, by distillation, since it is more volatile than most of the other substances present; the boiling point of Alcohol being 173° . Repeated distillations, are however necessary, to bring it up to any of the higher commercial standards which are denominated "80 pr. ct.," "95 pr. ct.," etc.

554. Alcohol is a volatile, pungent, colorless, liquid, and has never been frozen.

It mixes with water in all proportions and dissolves many substances which water does not; especially the volatile oils, and many resins, as well as some saline substances.

It is combustible, burns with a pale bluish light, and little smoke; producing very considerable heat, on which account it is used extensively as a source of heat in chemical processes: though coal gas where procurable, with a suitable arrangement for burning it, is cheaper and better.

Ill. 483. The distillation of a mixture of $C_4H_6O_2$, and water, is seen to furnish a liquid of less Sp. gr. than the original mixture, and containing a larger share of Alcohol.

Ill. 484. Solvent powers and combustibility of $C_4H_6O_2$.

555. Owing to its combustibility and volatility, the vapor of Alcohol readily mixes with air, and forms an explosive mixture.

552. First of the series and symbol? Source, names, and properties? 553. Name and symb. of common alcohol? Source and where described? Strongest commercial alcohol? *Absolute* and how produced? How is Alcohol separated from fermented liquor and principle? How brought to 80 per cent., etc.? 554. Properties? Frozen? Mixes how with water? Solvent powers? Burns how, and use? Distillation, 483? Ill. 484? 555. Explosive mixtures?

III. 485. Explosions of mixtures of air and vapor of $C_2H_5O_2$.

The *antiseptic* properties of Alcohol have been referred to as owing to its attraction for water, and its power of coagulating Albumin, on which it acts like Kreasote, corrosive sublimate, and other powerful chemical agents.

556. Since distilled and fermented liquors which necessarily contain Alcohol, are quite generally employed as beverages, it has become the business of Chemistry and Physiology to investigate, and decide upon the relations of Alcohol, as well as upon those of every other substance, to the animal economy.

The result of the investigation is, that Alcohol does not belong to any of the classes of substances that regularly supply the wants of the animal economy; that while all these substances are the product of either living vegetable or animal forces, Alcohol is not such a product; but is produced by a *fermentation*, which is itself the effect of the action of putrefaction; and, further, that Alcohol interferes with all the regular operations of the animal economy, and exerts a powerful influence on the heart, the brain, and all the chief organs of the body; and that a small quantity of pure Alcohol is capable of causing death.

Hence it is necessary to class this substance with those that are poisonous, like corrosive sublimate, Morphine, or Arsenic; which are only to be used, if at all, in those special cases where the demand for them is to be decided upon by an intelligent, unbiased, and judicious physician.

557. AMYLOL, $C_{12}H_{22}O_5$, is a substance obtained in the process for producing Alcohol from the fermentation of potatoes. It is a colorless, pungent, nauseous, oily, combustible liquid.

The other substances of this class are, practically quite unimportant, and the series is not yet complete.

There are acids corresponding to the Alcohols, and forming a more complete series.

ACIDS OF THE FORMULA $C_nH_nO_4$.

The first of these is

558. FORMIC ACID, $C_2H_2O_4$, which has been referred to (450) as a product of the nettle, and the ant, as well as of chemical processes. Next is

III. 485? Antiseptic properties? 556. To what class of substances does *not* Alcohol belong? How are these substances all produced? How is Alcohol? Action of Alcohol on the animal system? Pure Alcohol? Cases in which it is to be used, if at all? [557. Symb., source, and properties of Amylol? Practical use of other Alcohols?] What acids are mentioned, and their *formula*? Name and symb. of the first one? 558. Sources of Formic acid, and where referred to?

559. ACETIC ACID, $C_4H_4O_4$. This substance, in an impure form is known as *vinegar*; and has been referred to (526) as the product of the Acetous fermentations. It may be produced in a variety of ways; one of the most curious of which is by the action of Platinum black on the vapor of Alcohol in the sunlight.

Platinum black is merely metallic Platinum, as a black powder, precipitated on the negative pole of a battery from a solution of Chlorid of Platinum, or by the action of Carbonate of Soda, Sugar and heat upon the same solution.

When some Platinum black is placed beside a vessel of Alcohol under a bell-glass in the sun, the vapor of $C_4H_4O_4$ condenses upon the sides of the glass. In this case there is production of an intermediate substance, Aldehyd, $C_4H_4O_2$, hereafter to be noticed.

Also, if a coil of fine Platinum wire is suspended, when red-hot, in a glass above some ether, the wire continues to glow until the Ether is exhausted. The heat results from the chemical combinations, by which Acetic and Formic acids and other substances are produced.

560. The Acetous fermentation, for the production of vinegar, is managed in various ways. What is called *cider vinegar*, is produced sometimes, by the exposure of cider, the fermented juice of apples, in open casks, to the action of the air. The addition of ready formed vinegar, and of "*mother*," a fungous growth in vinegar, or of any ferment, hastens the process. In a similar way *wine vinegar* is formed.

Vinegar is produced rapidly, by causing liquids that have undergone the Alcoholic fermentation, to trickle over shavings, so that there is a free exposure to air, by means of which O. is more readily absorbed. (See 526, 527. &c.)

561. The *pyroligneous* acid referred to (547), is one of the principal sources of Acetic acid. It may be purified from the foreign substances that give it odor, by neutralization with Carbonate of Soda, crystalizing the Acetate of Soda formed, drying the crystals, and then distilling the dried salt, with strong Sulphuric acid. In a similar way, the acid may be extracted from common vinegar.

Pure Acetic acid crystalizes by cold; but, above 60° , is a colorless, intensely acid, corrosive liquid. Its salts are all soluble.

559. Symbol of Acetic acid, and common form? Curious method of production? Platinum black? Coil of Platinum wire? 560. Cider and wine vinegar, how made? "Mother"? Rapid production? 561. How from *pyroligneous* acid? Properties of pure Acetic acid?

III. 485, *a*. A coil of fine red-hot Platinum wire suspended in a test-glass over Ether, continues to glow while the Ether lasts.

Powerfully pungent odors arise from the Acetic and Formic acids, &c., produced.

III. 485, *b*. Specimen and properties of *commercial* Acetic acid, a dilute form.

562. ACETATE OF SODA, $C_4(H.Na)O_4$, just referred to, crystallizes in modified oblique rhombic prisms (321), containing six equivalents of water.

563. ACETATE OF ALUMINA, $C_4(H.Al)O_4$, is a salt extensively used in dyeing and calico printing, since, when fixed upon the cloth, a moderate heat expels the Acetic acid, and leaves the Alumina upon the cloth to act as a mordant.

MONACETATE OF IRON, $C_4(H.Fe)O_4$, and the *sesquiacetate*, $C_4(H_3Fe_3)O_4$, are used also in dyeing and calico printing.

564. ACETATE OF LEAD, $C_4(H_3Pb)O_4$, is a common substance known as *Sugar of Lead*, from its sweet taste. It is poisonous. The antidote is Sulphate of Magnesia (124).

Acetate of Lead is used in medicine, and for the preparation of some other compounds of Lead.

565. ACETATE OF COPPER, $C_4(H.Cu)O_4$, is a fine green salt, and one of the elements of verdigris, a common paint. It is poisonous, and the antidote is Albumin, or eggs (125).

By the substitution of 3 equivalents of Chlorine for 3 of Hydrogen, Chloracetic acid, $C_4(HCl_3)O_4$, a crystalizable substance is formed.

566. The acids of the formula, $C_nH_nO_4$, constitute a series almost complete. The Metacetic, Valeric, Stearic, and other acids, are examples. Below are others:—

Propionic acid, $C_3H_5O_4$ (called also Metacetic), is one of the results of the action of KO. on Sugar. It is a pungent, volatile liquid.

Butyric acid, $C_4H_7O_4$, is considered to be present in butter. It may be produced from butter, sugar or milk; and is a colorless, strongly acid liquid, of a rancid odor.

Valeric acid, $C_5H_9O_4$, exists in the root of the *Valeriana officinalis*. It may be produced, as with Acetic acid, by the action of Platinum black, on Amyl, instead of Vinol. It is an oil-like, acid liquid.

567. *Enanthylic acid*, $C_{11}H_{21}O_4$, is a fragrant, oil-like substance,—a result of the action of Nitric acid on *Castor oil*.

Caprylic acid, $C_8H_{17}O_4$, is thought to exist in butter.

Pelargonic acid, $C_{15}H_{31}O_4$, is found in the distilled water of the rose geranium (*Pelargonium roseum*). It is thought to be present in ether of wine, and to give the vinous flavor.

Capric acid, $C_{10}H_{21}O_4$, is one of the acids of butter.

Ethalic acid, $C_{12}H_{25}O_4$, is a white crystalline solid, extracted from *Spermaceti*.

Red-hot Platinum wire, 485, *a*? 485, *b*? [562. Symbol of Acetate of Soda, and crystalization? 563. Symb. and uses of Acetate of Alumina? The Acetates of Iron, their symb. and uses?] 564. Symb., properties, common name, and uses of Acetate of Lead? 565. Of Acetate of Copper? What is said of Chloracetic acid? 566. Examples of other acids homologous with Acetic? [Symb. and source of Propionic acid? Butyric? Valeric? 567. Enanthylic? Pelargonic? Capric?]

568. **STEARIC ACID**, $C_{34}H_{34}O_4$, is extracted from fat and tallow of various kinds. It is a hard white solid, requiring a temperature of 168° to fuse it; and is much used as a material for candles, being harder, and less readily fusible, than the fats, or their other elements. *Margaric acid* has the same composition, but is more readily fusible.

Bassic acid, $C_{36}H_{36}O_4$, is derived from human fat.

Cerotic acid, $C_{54}H_{54}O_4$, is a solid substance extracted from China wax.

Mellissic acid, $C_{60}H_{60}O_4$, is from beeswax. (See Appendix.)

569. Several other acids of this series are known. Acetic acid, $C_4H_4O_4$, when compared with Vinol or common Alcohol, $C_4H_6O_2$, from which it is derived, is seen to have two more equivalents of O, and two less of H. Formic acid, $C_2H_2O_4$, has the same relation to Methol, $C_2H_4O_2$, or wood spirit; and so, also, has Valeric acid, $C_{10}H_{10}O_4$, to Amylol, $C_{10}H_{12}O_2$, or potato spirit.

570. Several other Alcohols, corresponding to acids of the formula, $C_nH_nO_2$, are known; as, Propylol, $C_3H_4O_2$, corresponding to Propionic acid; Butylol, $C_4H_6O_2$, to Butyric acid; Caprol, $C_6H_8O_2$, to Caprylic acid; Ethol, $C_2H_4O_2$, to Ethalic acid; Ceretol, $C_{54}H_{54}O_2$, to Cerotic acid; and Mellissol, $C_{60}H_{60}O_2$, to Mellissic acid.

Caprol is a perfectly fluid, transparent, aromatic, combustible liquid. The other Alcohols, of a greater number of equivalents, are solid and of a fatty or waxy appearance.

571. Besides these Alcohols, homologous with common Alcohol, and having the formula, $C_nH_{n+2}O_2$, there are *other classes*; as, for example, those represented by $C_nH_{n-6}O_2$; as Phenol, $C_{12}H_{10}O_2$, a derivative from Salicin, and also contained in coal-tar, and in *castoreum*, a secretion of the beaver; Benzolol, or Anisol, $C_{14}H_{12}O_2$, from *benzoin* and essence of *anise*; and Cuminol, $C_{20}H_{14}O_2$, from the essence of *cumin*.

572. An important relation of the *boiling points* of substances, to their composition, has been found to exist. For example, Kopp maintains, as the result of his investigations, that Formic acid, $C_2H_2O_4$, boils at 99° of the *Centigrade* thermometer; Acetic, $C_4H_4O_4$, at $99^\circ + 19^\circ = 118^\circ C$; Butyric, $C_8H_8O_4$, at $99^\circ + 3 \times 19^\circ = 156^\circ$; and Valeric, $C_{10}H_{10}O_4$, at $99^\circ + 4 \times 19^\circ = 175^\circ$; while, in composition, Acetic acid contains C_2H_2 , in addition to Formic; Butyric, $3C_2H_2$; and Valeric, $4C_2H_2$; so that for each addition of C_2H_2 , the boiling point rises $19^\circ C$.

573. There are several other *homologous groups* of acids.

568. Symb., sources, properties, and uses of Stearic acid? Said of Margaric? [Bassic? Cerotic? Mellissic?] 569. Relations of Acetic, Formic, and Valeric acids to Vinol, Methol, and Amylol, respectively? [570. Other Alcohols of the same formula, and the acids to which they are related? Properties of Caprol?] 571. Examples of Alcohols of the formula $C_nH_nO_2$, and their sources? [572. Relations of composition to boiling point?] 573. Other homologous groups of acids?

HOMOLOGOUS ACIDS of the formula $C_nH_{n-2}O_4$. This group includes Oleic acid, $C_{18}H_{34}O_4$, from the *olein* of lard, a colorless insoluble liquid, as well as others.

Acrylic acid, $C_3H_4O_4$, from a variety of sources, is one of this group; Elaidic acid, $C_{18}H_{34}O_4$, is an isomeric transformation of the Oleic; Moringic, $C_{15}H_{28}O_4$, is from the oil of the plant *Moringia aptera*; Anthropic, $C_{31}H_{58}O_4$, is from human fat; and Dæglic acid, $C_{25}H_{46}O_4$, is from whale oil.

574. ACIDS of the formula $C_nH_{n-2}O_6$. To this group belong Ricinolic acid, $C_{36}H_{70}O_6$; and Ricinoleic, $C_{38}H_{70}O_6$, both from castor oil, which is from the plant, *Ricinis communis*.

575. ACIDS of the formula $C_nH_{n-2}O_8$. Succinic acid, $C_4H_6O_8$, from amber (Latin, *succinum*), belongs to this group.

Also, Adipic, $C_{12}H_{20}O_8$; Pimelic, $C_{14}H_{22}O_8$; Suberic, $C_{16}H_{24}O_8$, from cork (Latin, *suber*, the cork-tree); and Sebacic, $C_{20}H_{38}O_8$. These five acids may all be produced from *Oleic acid*.

576. ACIDS of the formula $C_nH_{n-8}O_4$. Benzoic acid, $C_{14}H_{10}O_4$ (453), belongs to this group.

Toluic, $C_{16}H_{14}O_4$, taking its name from *tolu* balsam, and Cuminic acid, $C_{20}H_{18}O_4$, from oil of *cumin*.

577. ACIDS of the formula, $C_nH_{n-4}O_8$. Camphoric acid, $C_{20}H_{16}O_8$, from *camphor*, belongs here.

578. ACIDS of the formula $C_nH_{n-8}O_6$. Salicylic acid, $C_{14}H_{10}O_6$, from Salicin, and other sources; and Anisic, $C_{16}H_{18}O_6$, from oil of *anise*, are examples.

ACIDS of formula $C_nH_{n-4}O_4$. Cinnamic acid, $C_{12}H_8O_4$, from oil of *cinnamon*, is an example.

579. Here then have been presented examples of eight homologous groups of acids, namely :

- | | |
|---|--|
| 1. Acetic acid group, $C_nH_{n-2}O_4$. | 5. Benzoic acid group, $C_nH_{n-8}O_4$. |
| 2. Oleic " " $C_nH_{n-2}O_4$. | 6. Camphoric " " $C_nH_{n-4}O_8$. |
| 3. Ricinolic " " $C_nH_{n-2}O_6$. | 7. Salicylic " " $C_nH_{n-8}O_6$. |
| 4. Succinic " " $C_nH_{n-2}O_8$. | 8. Cinnamic " " $C_nH_{n-4}O_4$. |

These groups afford an illustration of the numerous derivatives from natural organic substances; and exhibit something of their interesting and wonderful relations. But more of these are seen as we proceed. We may now enter upon the

An acid of the formula, $C_nH_{n-2}O_4$, its symb., source, and properties? [Symbols and sources of Elaidic acid? Moringic? Anthropic? Dæglic?]
 574. Acids of the formula $C_nH_{n-2}O_6$, their symbols and sources? 575. An acid of formula $C_nH_{n-2}O_8$? [Symbol and source of Adipic acid? Pimelic? Suberic? Sebacic?]
 576. An acid of formula $C_nH_{n-8}O_4$, and its symbol? [Toluic acid? Cuminic?]
 577. An acid represented by $C_nH_{n-4}O_8$?
 578. What two by $C_nH_{n-8}O_6$? One by $C_nH_{n-4}O_4$?
 579. Examples of how many homologous groups have been given? [Designate each group by some acid in it and give its formula!] What is illustrated by these groups of acids?

SOAPS, GLYCERIDS, AND ETHERS.

580. These three classes of substances exhibit some analogy to *inorganic salts* in composition.

THE SOAPS are *true salts*. Common soaps are salts of Potassa or Soda, in which the alkaline base is combined with several fatty acids, such as the Oleic, Stearic, Margaric, Butyric, Capric, etc. The salts which constitute soaps are therefore Oleate of Potassa, Oleate of Soda, Stearate of Potassa, Stearate of Soda, etc.

581. The soaps of Potassa are more soluble and form the greater portion of soft soaps. Those of Soda are less soluble and predominate in *hard* soaps. Most soaps contain some excess of alkali by which oily matters from the article to be washed, are also converted into soap, and rendered soluble. Lime soaps, as before noticed, are insoluble. There are soaps of Lead, of Ammonia, etc. Oils containing acids capable of forming soaps, are denominated *saponifiable* oils, such as *olive* and *palm* oil.

III. 486. Conversion of olive oil into a solution of soap by means of Potassa.

582. GLYCERIDS. This term is applied to the definite fats such as Stearin, Margarin, Butyrin, etc. (463 to 498). By decomposition they generally furnish

GLYCERIN, $C_3H_5O_3 = 92$. *Sp. gr.* 1.28. This is a sweet, soluble, colorless, thickish, non-volatile liquid. It has been recently employed somewhat in medicine and the arts, and is found to be chemically a deoxydizing agent. Its name is from *glukus*, sweet.

Glycerin is a product of the decomposition of the Glycerids, by which, with the absorption of $8H_2O$, they furnish two equivalents of the peculiar acid, and one of Glycerin.

ETHERS.

583. This a most extensive class of compounds which, for the most part, are highly volatile and fragrant liquids, though some have the solid form and others are gases. Many of them are natural products, often constituting the peculiar flavoring

Next subject? 580. To what are the *soaps, glycerids, and ethers* similar and how? Soaps are what? Common soaps are salts of what bases and with what acids? Salts which constitute soaps? 581. Soft and hard soaps? Action of soap in washing? Insoluble soaps? Saponifiable oils? 582. To what is the term glycerid applied? Examples? What do glycerids furnish and how? [In what way are glycerids decomposed to form Glycerin and an acid?] Next subject? 583. Extent, form, volatility, sources, and peculiarities of the *ethers*?

principles of fruits, vegetable, oils, etc.; but the larger number known are artificial.

They are generally produced by the action of acids on alcohols, and always retain a certain relation to the alcohol in composition, as will be hereafter seen. We may now enter upon their consideration.

584. ETHER, or *Vinic ether* $C_2H_{10}O_2 = 74$. *Sp. gr.* .725. This substance is a very common article, generally denominated "Ether." As Sulphuric acid is usually employed in its formation from Vinol, or common alcohol, it is sometimes called "Sulphuric ether;" but this term belongs to another substance, and is inappropriate for this, since it contains no S.

Ether may be formed by the distillation of a mixture of seven volumes of Sulphuric acid, with sixteen of Alcohol; keeping up the supply of the Alcohol by a continuous stream, as fast as the Ether comes over, and carefully maintaining the temperature at about 300° .

585. Ether is a colorless and very volatile liquid, boiling at 96° under atmospheric pressure, and at temperatures below the freezing point as the pressure is removed.

Intense cold results from the boiling of Ether *in vacuo*; and water may be frozen by this means. If the bulb of a thermometer is moistened with Ether, the Mercury rapidly runs down below the freezing point.

Ether is soluble in Vinol, and slightly in water; and being combustible and volatile, its vapor is very liable to take fire, and even to form dangerous explosive mixtures.

586. Ether is extensively used in the arts; in Medicine; and as an *anæsthetic*, or agent to cause insensibility to pain, in surgery.

Ill. 487. Continued process for the formation of Ether from Vinol.

Ill. 488. Color, odor, and solubility of Ether.

Ill. 489. Cold produced when Ether is dropped on the hand or the thermometer.

Ill. 490. Water frozen, in contact with boiling Ether, *in vacuo*.

Ill. 491. Combustibility and explosive properties of Ether.

587. CHLORINIC ETHER, C_4H_5Cl , called also *Chlorohydric ether*, is formed from Vinol, by saturation with HCl, and distilla-

From what produced and how? Composition? 584. Symb., equiv., and density of Ether? Sulphuric Ether? How formed? 585. Color, form, and boiling point of Ether? Production of cold? Solubility? Combustibility, etc.? 586. Use of Ether? Formation, 487? Specimen, etc., 488? Cold, 489? Water frozen, 490? 491? 587. Symb., formation, and properties of Chlorinic ether?

tion. It is a pungent aromatic liquid. Similar compounds containing C_4H_5I and C_4H_5Br , are readily formed.

588. SULPHURIC Ether, $(C_4H_5)_2S_2O_8$,—is a dense oily fluid, produced by the action of SO_3 on Ether.

ACID SULPHURIC Ether, $C_4H_5HS_2O_8$,—is a thick, acid liquid, generally called *Sulphorinic acid*, since it combines with inorganic alkaline bases, and forms salt, called Sulphovicates; as, for example, Sulphovicate of Lime $C_4H_5CaS_2O_8$.

589. NITRIC ETHER, $C_4H_5NO_6$, is a sweet, colorless liquid.

NITROUS ETHER, $C_4H_5NO_4$, is a volatile, fragrant liquid which may produced by the action of NO_3 on Alcohol. It is present in the preparation known as *sweet spirits of nitre*.

590. *Formulas of the Ethers.* It was mentioned (198, etc.), that the Hydrous Oxacids and Oxysalts are regarded as consisting of an anhydrous acid, united with water, to form the hydrous acid, or with the Oxyd of a metal to form the Oxysalt: thus, hydrous Sulphuric acid was supposed to consist of the anhydrous acid, SO_3 , and water HO : and Sulphate of Iron to be composed of anhydrous Sulphuric acid SO_3 , and Oxyd of Iron FeO . While it is certain that the Oxacids and Salts contain the elements referred to, and in the same ratio respectively, it is not entirely certain that either SO_3 or HO , exist, as such, in the hydrous acid, nor that FeO and SO_3 exist, as anhydrous Sulphuric acid, and as Oxyd of Iron, respectively, in the salt.

591. The formula, FeO,SO_3 , or HO,SO_3 , is put in this shape in accordance with a theory which certain facts seem to render probable, but to which certain other facts stand opposed.

The Oxysalts, etc., have been represented in this way, in order to conform to a custom which generally prevails among writers, which is in accordance with the names almost universally given to these substances; and to facilitate the progress of the learner, by having the symbol and the name to correspond.

592. Should we write Sulphate of Iron $FeSO_4$, and hydrous Sulphuric acid HSO_4 , it would equally well indicate the ultimate composition of those substances, without expressing any theory whatever.

For the salts of the vegetable acids the same plan was not followed: as it was thought that at that stage in the study, the learner would have become so familiar with names and symbols, as not to be disconcerted by an innovation.

593. It will have been noticed, doubtless, that the formulas of these salts can readily be arranged to correspond to the previous ones. Thus, neutral Oxalate of Potassa, $C_4K_2O_8$, may be written $2(KO,C_2O_3)$, or, which is the same thing as to ratios, KO,C_2O_3 ; and then we have Potassa KO , combined with hypothetic, anhydrous Oxalic acid C_2O_3 .

Other ethers? 588. Symb. and properties of Sulphuric ether? Names, symb., properties, and combinations of acid Sulphuric ether? 589. Symb. and properties of Nitric ether? Nitrous, and production? [590. Formulas of the Oxacids and Oxysalts and theory of their composition? What is certain and what not? 591. The formula FeO,SO_3 , why in this shape? Reasons? 592. In what other way are formulas written? The salts of the vegetable acids? 593. The formulas of these salts how made to correspond to those first given for Oxysalts?]

It is just possible, that C_2O_2 may yet be isolated so as no longer to be hypothetical: for NO was, for a long time, a hypothetical substance, and has only recently been obtained uncombined.

594. The acid Tartrate of Potassa, $C_4(HK)O_{10}$, may also be written, $KO.HO.C_4O_{10}$; in which case C_4O_{10} would be hypothetical, anhydrous Tartaric acid, and so with the others. The formulas $C_4(H_2K)O_{10}$ and $C_4K_2O_8$ have the advantage of being simpler, and also of corresponding to those of the acids. The theory of the replacement of an atom of H , by one of K , would still be the same.

595. In reference to the composition of the Ethers, a theory similar to that followed in the symbols of the inorganic acids and salts, has been advanced.

Thus C_2H_3Cl may be regarded as a Haloid salt, the Chlorid of a base represented by C_2H_3 , and which has been called *Ethyl*; but if it were necessary to give this base a name, a much better one indicating its origin would be *Vinyl*. Then the Chlorinic ether would be *Chlorid of Vinyl*, and so Sulphuric ether would, instead of $(C_2H)_2S O_4$, be $2(C_2H O.SO_2)$ or $C_2H O.SO_4$; and its theoretical composition would be like that of Sulphate of Iron; namely, anhydrous Sulphuric acid, SO_4 , combined with the Oxyd of Vinyl.

This simplifies names somewhat, but it renders the symbols rather more complex, and teaches a theory that it is at present impossible to establish; still, however, C_2H_3 , like a large number of similar hypothetical, or actual compounds, does certainly replace H , and is replaced by it, and by a metal; as though it were a simple substance.

597. The recent isolation of C_2H_3 , and of other groups of a similar character, increases the probability of the *actual existence* of many substances now hypothetical. The term, *compound radicle*, is applied to any group that appears to act as a simpler organic element. While there are certain advantages connected with the employment of compound radicles, their free use is open to several objections.

598. To render the formulas somewhat more familiar we may throw those of the other Ethers referred to, into the same *binary* form, leaving the student to name them as may best please him.

Acid Sulphuric Ether would then be $C_2H_3O.HO.2SO_4$, and might be called *Acid Sulphate of Vinyl*, corresponding to the acid Sulphate of Potassa, $KO.HO.2SO_4$; and *Sulphovinate of Lime*, $C_2H_3CaS_2O_8$, would become the double Sulphate of Vinyl and Lime, $C_2H_3O.CaO.2SO_4$. Also, *Nitric ether*, would be $C_2H_3O.NO_5$; and *Nitrous*, $C_2H_3O.NO_3$. Common ether, $C_2H_5O_2$, or C_2H_5O , would be the Oxyd of Vinyl. But to return to an account of the Ethers.

599. *The Phosphoric Ethers* correspond to the Phosphates; the neutral ether being $(C_2H)_3PO_4$, or $3C_2H_5O.PO_4$; while the acid ethers or Phosphovinic acids, are $C_4H_3PO_5$, or $C_2H_3O.2HO.PO_3$; and $C_2H_3PO_6$, or $2C_2H_3O.HO.PO_3$.

Carbonic Ether is $C_6H_6O_6$, which, dividing by 2 equals $C_2H_3O_3$ or $C_2H_3O.CO_2$.

There are two volatile liquid *Silicic Ethers*; $(C_2H_3)_3SiO_3$ and $C_2H_3Si_2O_7$; and also a *Boracic Ether* which gives the green color to the flame of Alcohol (237).

[Oxalate of Potassa and hypothetical Oxalic acid? 594. Acid Tartrate of Potassa, etc.? 595. Theory of the composition of the ethers? Names for C_2H_3 ? Names for the ethers? 596. Advantages and objections? Replacements? 597. General name for these hypothetical compounds? Free use? 598. Formulas of the ethers after the type of those first given for the Oxydals? Examples? 599. Phosphoric ethers? Carbonic? Silicic? Boracic?]

600. ACETIC ETHER, $C_4(HC_2H_3)O_2$, is Acetic acid, $C_4H_4O_4$, with one equivalent of H. replaced by the group, C_2H_3 .

It is fragrant and volatile, and generally contributes to the flavor of common vinegar.

Formic ether, $C_2(H, C_4H_3)O_4 = C_6H_6O_4$, is of the same ultimate composition as *Propionic acid*, but is quite a different substance. An *ether* of the same composition as the *Formic*, is shortly to be noticed.

601. These examples of the Ethers of Vinol give some indication of the composition and number of the ethers of Alcohols generally.

It will be remembered that Vinol is $C_4H_6O_2$, and that of these elements, C_4H_5 , have entered into the composition of all the ethers. In the substance called, simply, *Ether*, $C_4H_{10}O_2$, and which by way of distinction may as well be termed *Vinic ether*, the elements C_4H_5 , are doubled and united with O_2 .

602. Vinic ether might as well be written C_4H_5O , did not the specific gravity of its vapor, as well as some other reasons, indicate that its proper formula is $C_8H_{10}O_2$. In either case, it may for the purpose of illustration merely, be regarded an Oxyd of C_4H_5 , as before mentioned, and written VnO or Vn_2O_2 . We might suppose that as we have an Oxyd there might also be a Sulphuret, or at least that S. might replace O; and accordingly, a Sulpho-vinic ether $C_8H_{10}S_2$ has been formed; as well as others, $C_8H_{10}Se_2$ and $C_8H_{10}Te_2$; and also, $C_8H_{10}S_4$ which corresponds to HO_2 (170) or $2HO_2$; for C_4H_5 and H. may mutually replace each other. $(C_4H_5)_2$ then, takes the place of H_2 , in $2HO_2$; and S₄ replaces $2O_2$, so that $C_8H_{10}S_4$ corresponds to $2HO_2$.

603. This replacement is seen, in a remarkable manner, in Vinol, $C_4H_6O_2$, itself, which may become $C_4H_6S_2$ or Sulphur alcohol. This has been called *mercaptan*, from *mercurium captans*, seizing Mercury, on account of its attraction for Mercury by which it becomes $C_4(H_5Hg)S_2$.

In Vinol, Potassa may replace Hydrogen to produce Monopotassic Vinol, or $C_4(H_5K)O_2$.

604. THE METHYLIC ETHERS. These are similar in composition to the Vinic ethers, but being derived from Methol, $C_2H_4O_2$, they contain C_2H_3 , instead of C_4H_5 .

Methylic ether, $(C_2H_3)_2O_2 = C_4H_6O_2$, though of the same formula and composition as common alcohol, has the gaseous form.

The *Chloromethylic ether*, or Chlorid of Methyl, C_2H_3Cl , is a colorless gas,

600. Symb., form, properties, and flavor, of Acetic ether? [*Formic ether*?]

601. Ethers of Vinol indicate what? Symb. of Vinol, and which of its elements enter into all the ethers? In *Vinic ether*? 602. Why written $C_8H_{10}O_2$? Replacement of O. by S? Se? Te? How does $C_8H_{10}S_4$ correspond to $2HO_2$? [604. Replacements of O. and H. by S, Hg, and K, in Vinol, and compounds formed? 604. Compare the *Methylic ethers* with the *Vinic*? An ether isomeric with Alcohol? *Methylic ethers* containing Cl, Br, and I?]

while the Methyl ethers containing Br. and I. are liquids. The *acid Sulphomethylic ether*, or Sulphate of Methyl, is $C_2H_5SO_4$, or $C_2H_5O_4HIO_2SO_3$.

The *Aceto-methylic ether*, $C_2(H_3C_2H_5)O_4 = C_2H_5O_4$, though of the same composition as the Formo-vinic (600), yields different products when decomposed.

605. AMYLIC ETHERS. These are formed from Amylol, $C_{10}H_{12}O_2$. Their characteristic constituents are, therefore, $C_{10}H_{11}$, instead of C_4H_5 as in the Vinic ethers, or of C_2H_3 in the Methylic.

Chloramyllic ether, $C_{10}H_{11}Cl$, is a colorless oil, boiling at 247° . The *Valero-amyllic ether* has the flavor of the apple and the Aceto-amyllic, a volatile, colorless, liquid, has that of a variety of the pear. Both are employed in perfumery and confectionary, as well as several other ethers.

606. Since it is possible, that each of the Alcohols may yield grouped elements like C_2H_3 , C_4H_5 and $C_{10}H_{11}$, which may combine with all the known acids to form ethers, the number of this class of compounds is very great. Next in order is the class of

ALDEHYDS.

607. These may be represented by

VINIC ALDEHYD, $C_4H_4O_2$, a substance differing from common alcohol, $C_4H_6O_2$, by having two less equivalents of Hydrogen; hence it has been named Aldehyd; that is, Alcohol de-hydrogenated, or Alcohol from which H. has been separated.

This substance may be produced by distillation from equal weights of Bichromate of Potassa and Alcohol, to which one and a half parts of Sulphuric acid are slowly added. In the impure product, the properties of $C_4H_4O_2$ are sufficiently evident for illustration.

608. Aldehyd is a colorless, volatile, combustible liquid, having a strong and peculiar odor. It is an intermediate product in the formation of Acetic acid (559).

When pure, $C_4H_4O_2$ is not permanent, but changes to other substances isomeric with it, and having different properties. These are an oily liquid, *Ethaldehyd*, $C_6H_6O_2$, and a solid, *Metaldehyd*, $C_{16}H_{16}O_8$.

III. 492. Formation and properties of Aldehyd.

[Acid Sulpho-methylic ether? Aceto-methylic and Formo-vinic?]

605. Characteristic elements of the Amylic ethers? Chloramyllic, or Chlorid of Methyl? Properties and uses of the Valero-amyllic and Aceto-amyllic ethers? 606. What ethers are possible? Next subject? 607. Representative of the *aldehyds*, and symbol? Common alcohol and its aldehyd? Names? Production? 608. Properties? [Permanency? Ethaldehyd? Metaldehyd?]
III. 492?

609. Aldehyd, like Alcohol and the ethers is subject to a variety of changes by replacement; that is, by certain processes, compounds may be formed having the same type, $X_1Y_1Z_1$, but containing other elements. Among these are the following:

610. *Chloral*, $C_2(HCl)_3O_2$, is an oily liquid obtained by the action of Cl. upon anhydrous Alcohol. It is Aldehyd with an equivalent of H. replaced by Chlorine. In *Sulphur aldehyd*, $C_2H_4S_2$, the O_2 is replaced by Sulphur. There is also Potassic aldehyd, $C_4(H_3K)O_2$.

The aldehyd corresponding to Methol, would be $C_2H_4O_2$, but is unknown, except in the Bichlorinic form, $C_2Cl_2O_2$, which is called *Phosgen gas*.

611. *Amylic aldehyd*, $C_6H_{12}O_2$, an oily liquid, may be obtained from Amylol by a process similar to that for the Vinic aldehyd. Other Aldehyds are known; and it is to be expected, that for every alcohol an aldehyd may yet be discovered.

612. *Homologues of Aldehyd*, $C_nH_{2n}O_2$. There are several of these substances, which in composition are homologous to Aldehyd, but we have space for one only.

Aceton, $C_2H_4O_2$, is a light, colorless, combustible, liquid, which may be produced by the action of heat on Acetate of Lime.

It will be proper next to consider certain artificial substances related to the alcohols, ethers, &c., which may be denominated

ARTIFICIAL VOLATILE VEGETABLE PRODUCTS.

613. Bitter Almond oil, oil of *Spiræa Ulmaria*, oil of mustard, &c., may be considered under this head.

BITTER ALMOND OIL, $C_{14}H_{16}O_2$, is a substance produced by distillation from a paste of bruised bitter almonds. The oil is formed in the process, since it does not exist in the kernels.

It is a colorless, odorous, pungent oil; containing, in the crude state, a quantity of the deadly poisonous Hydrocyanic acid. Purified from this, it is employed for scenting soaps and for a variety of purposes. It is often denominated *Benzoilol*.

614. This oil, by chemical means, is made to undergo a variety of transformations. Cl. may replace an atom of its H, thus converting it to Chlorinic Benzoilol, $C_{14}(H,Cl)O_2$. It may also be converted into an isomeric white crystalline solid, called *Benzoin*, $C_{28}H_{42}O_4$. Benzoic acid (453) results from the Oxidation of the oil.

615. OIL OF SPIRÆA ULMARIA, $C_{14}H_{16}O_4$, is a product of decomposition and distillation from the flowers of the plant, and may also be produced from Salicin. The oil is called Salicylol.

It is a thin, colorless, fragrant oil, heavier than water. It is a source of Salicylic acid which, with Methyl, forms an ether present in the wintergreen, *Gaultheria procumbens*.

[609. Replacement? 610. Symb., source, and properties of Chloral? How an aldehyd? Sulphur aldehyd? Potassic? The aldehyd of Methol? 611. Symb., production, and properties of Amylic aldehyd? Other aldehyds known and to be discovered? 612. Homologues of Aldehyd? Symb., properties, and production of Aceton?] Next subject? 613. Substances under the head of Artificial vegetable products? [Symb., source, and properties, of bitter almond oil? Crude oil, why poisonous? Use? Transformations? 615. Symb., sources, and properties of Salicylol? Wintergreen?]

616. *Oil of Mustard*, $C_4H_7NS_2$, is an acrid oil, produced by decomposition and distillation from mustard, *Sinapis nigra*.

The oils produced from other *cruciferous* plants, as well as the oil of mustard, contain Sulphur. Rapeseed oil, from different species of *Brassica*, is one of the best oils for illuminating purposes.

A variety of compounds, consisting of Carbon and Hydrogen only, are produced by various transformations of substances previously noticed. These may be briefly referred to in connection with each other, under the head of

CARBO-HYDROGENS. AND THEIR MODIFICATIONS.

617. These may be arranged in groups.

1st. *Substances Isomeric with Etheren*, C_nH_n .

The following are examples:—

1. Etheren, C_2H_4 .
3. Amylen, C_5H_{10} .
5. Oil of Roses, $C_{20}H_{40}$.
2. Butyren, C_4H_8 .
4. Napten, $C_{10}H_{20}$.
6. Ceten, $C_{32}H_{64}$.
7. A product from Caoutchouc, $C_{40}H_{80}$.

This group strikingly illustrates isomerism, as all these substances, possessing different properties, have the same per cent. composition, their symbols being all in the ratio of CH, or an equivalent of Carbon = 6, to an equiv. of Hydrogen = 1; and one hundred pounds of any one of them, contain 85.7142 lbs. of C, and 14.2857 of H.

618. *Oil of roses*, which is, however, a natural substance, is considered the same in ultimate composition as Etheren, one of the chief constituents of *coal gas*.

There is a *Chlorid of Carbon*, C_4Cl_4 , corresponding in composition to Etheren; also, *Monochlorinic Etheren*, C_4H_3Cl , and *Bichlorinic Etheren*, $C_4H_2Cl_2$, etc.

2d. *The Formen group*.

619. Formen, C_2H_4 , has already been described (534). A series of substances corresponding with it, but in which H. is replaced, may here be noticed.

Terchlorinic Formen, C_2HCl_3 . This substance is generally called *Chloroform*, and, like Vinic ether, has become well known for its *anæsthetic* properties.

Chloroform is produced by distillation from a mixture of *bleaching powder* (204), water, and Alcohol, and subsequent purification. It is a heavy, oil-like liquid of sp. gr. 1.5, boil

[616. Oil of Mustard? Oils from cruciferous plants? Rapeseed oil?] Next subject? 617. 1st group of Carbo-Hydrogens, and examples? Isomerism? 618. Oil of roses? [Chlorinic modifications of Etheren?] What group succeeds? 619. Symb. of Formen? Trichlorinic Formen—symb., name, and why well known? Production and properties of Chloroform?

ing at 142° , having a sweetish ethereal odor, and but slightly soluble in water.

It seems to be a more energetic and dangerous anæsthetic agent than Ether; and, in many instances, its employment has resulted in death. It has a variety of medical uses.

Teriodinic Formen, or *Iodoform*, C_2HI_3 , is a solid, and *Terbrominic Formen*, a volatile, liquid substance.

It is to be remarked that *Formen*, C_2H_4 , is intimately related to *Formic acid*.

620. 3d. *Carbo-Hydrogens of the formula C_nH_{n-6}* . These are, *Benzen*, *Toluen*, &c.

Benzen, $C_{12}H_6$, sp. gr. .83, is a colorless oil, boiling at 187° . It may be formed from Benzoic acid, and is also a product of the process for obtaining illuminating gas. It is also called benzol.

Toluen, $C_{14}H_8$, is a derivative from Toluic acid, and from balsam of Tolu; *Cumen*, $C_{12}H_{10}$, is from Cuminic acid (576); *Cymen*, $C_{20}H_{14}$, is from oil of cumin.

621. *Other Carbo-Hydrogens and their modifications.*

Aceten, C_4H , is a volatile, oily, liquid, derived from Chloro-vinic ether, $(C_4H_5)Cl$, to which it corresponds, as $(C_4H_5)H$. In its production, $(C_4H)K$ is previously formed. A carbo-hydrogen of the formula $C_5H_{10}=2(C_4H_5)$ has also been produced.

622. By the action of Cl. on Etheren, and successively upon the products, a series of compounds, as *Biclorinic Etherilen*, $C_4H_4Cl_2$; *Terechlorinic Etherilen*, $C_4H_2Cl_4$; *Quadrichlorinic Etherilen*, $C_4H_2Cl_4$, &c.; and, finally, C_4Cl_6 are formed.

From *Chloro-vinic ether*, $(C_4H_5)Cl$, a similar series is formed, but having different properties.

From *Napthalen*, $C_{10}H_8$, another series corresponding in type, to *Napthalen*, results; and in some cases many different isomeric modifications, or different substances of precisely the same formula, have been noticed; so that the three elements, C, H, and Cl, may be combined into an indefinite number of compounds.

623. **CHLORIDS OF CARBON.** Of these there may be mentioned, the following:—

Formen Chlorid of Carbon, C_2Cl_4 , is a liquid, sp. gr. 1.6, boiling at 192° .

Etheren Chlorid of Carbon, C_4Cl_4 , a heavy, volatile liquid of sp. gr. 1.55, boiling at 160° .

Aceten Chlorid of Carbon, C_4Cl_4 , is a white crystalline solid, fusing at 320° , and subliming at 360° , unchanged.

Napthalen Chlorid of Carbon, $C_{20}Cl_8$, corresponds to *Napthalen*, $C_{20}H_8$ (549) in composition.

The modifications of Ammonia, by which a great variety of substances arise, may next be noticed under the head of

ARTIFICIAL ORGANIC ALKALOIDS.

624. Many of these come from the replacement of the H. of

Danger? [Other transformed Formens?] *Formen* and *Formic acid*? [620. Other group of *Carbo-Hydrogens*? *Benzen*—symb., properties, and sources? *Toluen*? *Cumen*? *Cymen*? 621. *Aceten*? 622. *Chlorinic Etherilens*? *Napthalens*? Combinations of the three elements, C, H, and Cl? 623. *Chlorids of Carbon*—*Formen Chlorid*? *Etheren*? *Aceten*? *Napthalen*?] Next subject? 624. Sources of the Artificial Organic Alkaloids?

Ammonium, NH_4 (253), by such a group of elements from the alcohols, as is found in the ethers; as, for example, C_2H_3 , C_4H_5 , or $\text{C}_{10}\text{H}_{11}$.

There are, however, precisely similar replacements by Cu, Ag, Hg, &c.

625. Thus, as there is Chlorid of Ammonium, NH_4Cl , so, also, there is Chlorid of Cuprammonium, $\text{N}(\text{H},\text{Cu})\text{Cl}$; and Chlorid of Bihydargic Ammonium, $\text{N}(\text{H},\text{Hg})\text{Cl}$, a substance precipitated by adding Ammonia water to a solution of Chlorid of Mercury, and known commonly as *white precipitate*.

626. The Chlorids of Platinammonium, are still more striking examples; as, $\text{N}(\text{H},\text{Pt})\text{Cl}$, a green salt; and, also, $\text{N}(\text{H},\text{PtNH}_4)\text{Cl}$, in which NH_4 replaces H. In another compound, Cl, NH_4 , and Pt, each replace H; thus, $\text{N}(\text{H},\text{Pt},\text{NH}_4\text{Cl})\text{Cl}$.

These are quite different from the double Chlorid of Ammonium and Platinum, $\text{NH}_4\text{Cl}, \text{PtCl}_2$, the common orange precipitate (255).

627. METHAMMIN, $\text{N}(\text{H}_2, \text{C}_2\text{H}_3) = \text{NC}_2\text{H}_5$; *Eq.* 31; sp. gr. 1.1. This is a colorless, highly soluble, and liquefiable gas, having a strong, Ammonia-like odor, and an alkaline reaction. It is combustible, burning with a yellow flame, and producing Carbonic acid, water, Ammonia, Nitrogen, and other products if the combustion is incomplete. The gas may be prepared from the Chlorid of Methammonium, $\text{N}(\text{H}, \text{C}_2\text{H}_3)\text{Cl}$, just as Ammonia was obtained (249) from the Chlorid of Ammonium, NH_4Cl .

628. Its resemblances to Ammonia, NH_3 , are very strong. It is even more soluble in water than NH_3 , or than any other known gas, since water dissolves more than 1,000 volumes of it. Like NH_3 , it is caustic, and is a strong base. It may be regarded as Ammonia, in which Methyl, C_2H_3 , has replaced H; but other theories have been advanced. It forms compounds similar to those of NH_3 ; as, for example, Chlorid of Methammonium, $\text{N}(\text{H}, \text{C}_2\text{H}_3)\text{Cl}$; and Nitrate of Methammin, $\text{N}(\text{H}_2, \text{C}_2\text{H}_3)\text{O}, \text{NO}_3$, a salt crystalizing in beautiful right rhomboidal prisms, which bear a resemblance to those of Nitrate of Ammonia (258). There are also Binmethammin, $\text{N}(\text{H}, 2\text{C}_2\text{H}_3)$, and Termethammin, $\text{N}(\text{C}_2\text{H}_3)_2$, in which two and three equivalents of H. are replaced by two and three, C_2H_3 , respectively.

629. VINAMMIN, $\text{N}(\text{H}, \text{C}_4\text{H}_5) = \text{NC}_4\text{H}_7$; *Eq.* 45; sp. gr. .69; water, 1. This is a transparent, colorless liquid, having the properties and reactions of NH_3 , and appears to be that substance, with H, replaced by Vinyl, C_4H_5 .

There are also *Bivinammin*, $\text{N}(\text{H}, 2\text{C}_4\text{H}_5)$, *Tervinammin*, $\text{N}(\text{C}_4\text{H}_5)_3$, and a variety of salts, &c.

Arylammin, $\text{NH}_4(\text{C}_6\text{H}_5)$, is another of this series. Besides these, there are many other modifications of Ammonia, as $\text{N}(\text{C}_2\text{H}_3, \text{C}_4\text{H}_5, \text{C}_6\text{H}_7)$, &c., &c.

630. In compounds of this series the N. may be replaced by Antimony, Sb; Phosphorus, P; or Arsenic, As; producing, for example, Stibtermethammin, $\text{Sb}(\text{C}_2\text{H}_3)_2$; Phosmethammin, $\text{P}(\text{H}_2, \text{C}_2\text{H}_3)$; Arsentermethammin, $\text{As}(\text{C}_2\text{H}_3)_3$.

An interesting series of compounds containing Arsenic, C, and H, have been discovered; as, AsC_4H_5 , AsC_4H_7 , AsC_4H_9 , $\text{AsC}_4\text{H}_{11}$; also, $\text{AsC}_4\text{H}_5\text{O}$, and $\text{AsC}_4\text{H}_7\text{O}_4$. Of these, two or three may be noticed.

631. *Metharsammin*, AsC_4H_5 , is a heavy, colorless, oil-like liquid; but crystalizable and highly poisonous. It corresponds to Dr. Kane's radicle,

{ 625 Examples of the replacement of the H. of NH_4 by Cu, and Hg? White precipitate? 626 Chlorids of Platinammonium? 627. Symb. and properties of Methammin? 628 Resemblances to NH_3 ? Compounds? Binmethammin? Termethammin? 629. Symb. and properties of Vinammin? Bivinammin? Tervinammin? Arylammin, &c. 630 Replacement of the N. of Ammonia by Phosphorus &c. Compound formed? Series containing Arsenic? 631. Metharsammin; names and symbol?

Amidogen, NH_2 , in which N. is replaced by As, and H. by C_2H_3 . Its formula may be written, $\text{As}(\text{C}_2\text{H}_3)_2$. Bunsen's name, *Kakodyl*, evil matter, is too fanciful and indefinite.

632. *Oxyd of Metharsammen*, $\text{As}(\text{C}_2\text{H}_3)_2\text{O}=\text{AsC}_4\text{H}_6\text{O}$, or *alkarsin*, is a heavy, colorless, offensive, oil-like liquid.

Arsenacetic acid, $\text{C}_4(\text{AsH}_3)_2\text{O}_4=\text{AsC}_4\text{H}_7\text{O}_4$, *alkargen*, or *kakodylic acid*, is a substance crystalizing in colorless, oblique rhombic prisms. It is soluble in water, has an acid reaction, and forms salts in which H. is replaced by a metal. It is not poisonous like the preceding. It may be considered to be Acetic acid, in which AsH_4 replaces H.

These substances come, originally, from the action of Arsenious acid on Acetate of Potassa, or from some similar source. They are evidently related to the substances that immediately precede. They have numerous derivatives which can not be here noticed.

633. *Glycecoll*, $\text{C}_4\text{H}_5\text{NO}_3$, or *Sugar of glue*, is a crystalizable substance, having a sweet taste; and it is produced by the action of Potassa on *glue*. Among other views as to composition, it has been regarded as Acetic acid, in which NH_2 replaces H. It has a variety of derivatives.

AMIDS.

634. These may be defined as Ammonia salts, minus 2HO for each equivalent of NH_4 . Thus, Acetate of Ammonia, $\text{C}_4(\text{H}_3\text{NH}_4)_2\text{O}_4-2\text{HO}$, is Acetamid, $\text{C}_4\text{H}_5\text{NO}_2$.

Acetamid is a volatile and crystalizable substance, produced by the action of Ammonia water on Acetic ether.

Oxamid, $\text{C}_4\text{N}_2\text{H}_4\text{O}_4=\text{Oxalate of Ammonia}$, $\text{C}_4(\text{NH}_4)_2\text{O}_8-4\text{HO}$. This is a white, neutral solid, produced by heating Oxalate of Ammonia. These two cases may serve to illustrate a class which furnishes many other examples and derivatives.

NITRYLS.

635. These are Amids, minus 2HO for each equiv. of NH_4 in the original salt. The Monoxyd of Nitrogen, NO (158), is the Nitryl of Nitrate of Ammonia, $\text{NH}_4\text{O}_4\text{NO}_5$; for, taking 4HO from this, there remain $2(\text{NO})$.

Aceto-Nitryl, $\text{C}_4\text{H}_5\text{N}=\text{Acetate of Ammonia}$, $\text{C}_4(\text{H}_3\text{NH}_4)_2\text{O}_4-4\text{HO}$. This is a volatile, colorless liquid, produced by distillation from Acetate of Ammonia and anhydrous Phosphoric acid.

Protein, a Nitryl of Cellulose. This interesting theory, sustained by several facts, is illustrated thus: Cellulose, $\text{C}_{24}\text{H}_{20}\text{O}_{20}+3\text{NH}_3-12\text{HO}=\text{Protein}$, $\text{C}_{24}\text{H}_{17}\text{N}_3\text{O}_8$.

636. **NITROUS CELLULOSE**, or *gun cotton*. Two modifications are known, $\text{C}_{24}(\text{H}_{16},4\text{NO}_4)_2\text{O}_{20}$, and $\text{C}_{24}(\text{H}_{14},6\text{NO}_4)_2\text{O}_{20}$; the former insoluble, the latter soluble in mixed alcohol and ether. [On comparison of the formulas of the gun cottons, with that of Cellulose, $\text{C}_{24}\text{H}_{20}\text{O}_{20}$, it is seen that a portion of the H. of Cellulose is replaced by NO_4 .]

Gun cotton is prepared by mixing $1\frac{1}{2}$ fluid ounces of Sulphuric acid, with the same measure of strong Nitric acid, immersing 100 grains of clean dry cotton in the cold mixture for five minutes, and then washing the cotton entirely free from acid, and drying it. Gun cotton appears like ordinary cotton,

632. Alkarsin. name, symb., and properties? Arsenacetic acid? Sources of these compounds? 633. Name, symb., sources, and properties of Glycecoll? 634. Definition of Amids? Correspondence of Acetamid to Acetate of Ammonia? Properties of Acetamid? Composition of Oxamid? 635. What are Nitryls? How is NO a nitryl? Composition and properties of Aceto-Nitryl? Protein a nitryl? Gun cotton; names, symbols, preparation, and properties?

but is more harsh. It takes fire at 376° , and sometimes as low as 212° , and, burning instantly, forms a large volume of Carbonic acid, Carbonic Oxyd, and Nitrogen: thus it has great explosive power. The solution of gun cotton, known as *collodion*, forms an excellent artificial cuticle, where that layer of the skin has been accidentally removed, since the solvents evaporate and leave an impervious film.

ARTIFICIAL ORGANIC COLORING MATTERS.

637. *Litmus*, *archil*, *cudbear*, *tournesol*. These are modifications of essentially the same coloring principle which may be derived from many different plants of the lichen kind.

Some of these are the *Rocella tinctoria*, which grows on maritime rocks on the south coast of France; the *Rocella fuciformis*, from similar situations on the South American and African coasts, as well as other species of the same genus; also, the *Lecanora tartarea*, *L. parella*, and *Gyrophora murina*, from mountainous rocks in North Europe.

638. The coloring matter, which consists of the four elements, O, C, H, and N, is developed from these by fermentation, and the admixture of substances containing Ammonia. It varies in tint from red to purplish blue, according to the mode of preparation. Alkalies give it the blue tint, but acids neutralize the alkali and restore the red.

639. INDIGO, $C_{16}H_7NO_2$. This well-known blue coloring principle is derived from several plants, chiefly of the East and West Indies, Africa, and Central America.

These plants are some dozen different species of *Indigofera*, besides the *Nerium tinctorium*, the *Isatis tinctoria* or woad of Europe, and the *Polygonum tinctorium*.

It is mostly in the leaves of these that the coloring principle is deposited. While the life of the leaf continues, the principle has no color, but as decay begins, the blue color is developed.

Indigo is insoluble in water, and must be changed to some soluble condition before it can be used in dyeing. In the processes of dyeing, and by other chemical means, a variety of substances are derived from Indigo.

640. *Indigogen*, $C_{16}H_{12}N_2O_4$. This is a soluble substance, having little color, and produced by various means: as, by the action of Lime and Monosulphate of Iron, on Indigo. It contains 2 equivs. of Indigo, plus H_2 . By exposure to air, it absorbs O_2 , and forms $2HO$, and 2 equivs. of Indigo. In the usual process of dyeing Indigo blue, the Indigo is converted to Indigogen, the article to be dyed is immersed into a bath of this, and then precipitation of the Indigo in the texture is effected.

641. *Sulphindyllic acid*, $C_{16}H_5NO_4 \cdot 2SO_3$, is the chief product when Indigo is dissolved in an excess of Sulphuric acid. It is of a blue color, is soluble in excess of acid, but not in water, and forms blue-colored salts.

Sulphopurpuric acid, $C_{16}H_{10}N_2O_4 \cdot 2SO_3$, is the chief product by the action of Sulphuric acid on an excess of Indigo. It is soluble in water, but not in dilute acid. It forms blue salts. These two acids are employed in dyeing the chemical or *Saxon blue*.

Isoatin, $C_{16}H_5NO_4$, is an orange-red soluble substance, formed from Indigo by the action of Chromic acid or dilute Nitric acid.

642. Chlorine bleaches Indigo by replacing a portion of its Hydrogen, and forming colorless or slightly-colored substances, containing Cl.

There are a great variety of other coloring matters, the study of which will be found highly interesting to the scholar, and valuable to the dyer.

[Collodion?]

637. *Litmus*, *archil*, &c.? [Sources?] 638. Composition, tints, effects of acids and alkalies? 639. Symb. and source of Indigo? [Plants?] In what part of the plant, and color? [Solubility?] 640. *Indigogen*; symb. and properties? Dyeing? 641. Symb. and properties of *Sulphindyllic acid*? *Sulphopurpuric*? *Saxon blue*? *Isoatin*? 642. Action of Chlorine?]

CYANOGEN AND ITS DERIVATIVES.

643. **CYANOGEN**, C_2N . *Eq.* 26. *Sp. gr.* 1.86. *Air*, 1. This substance is found in nature as an element of Cyanid of Hydrogen, and of other compounds, and is produced by a variety of reactions. It may be obtained by heating a mixture of three parts of corrosive sublimate and two of perfectly dried Ferrocyanid of Potassium, and collected under air (as in fig. 15, p. 27).

644. Cyanogen is a colorless gas, but liquefiable and solidifiable, and freely soluble in water. It has a peculiar pungent odor, something like that of peach pits, and is irritating and poisonous. It is combustible, burning with a fine carmine-colored flame. It forms an explosive mixture with two volumes of O, and the products of its perfect combustion, are Carbonic acid and Nitrogen. It is capable of combining with simple substances, and it forms a great variety of compounds, some of which have a blue color, whence the name, *Cyanogen, a producer of blues*.

645. **CYANID OF HYDROGEN**, HC_2N , is commonly known as Prussic acid, and Hydrocyanic acid. It results from the distillation of the soaked kernels of bitter almonds, peaches, apricots, plums, cherries, and quinces; of the blossoms, leaves, and young shoots of some of these, and other plants. If it exists at all in these, originally, it is only in very small quantity; and it seems to be generally the result of chemical changes. It may be produced pure, and in larger quantities, in other ways.

Pure Cyanid of Hydrogen is a light, volatile, colorless liquid, having a powerful odor, like that of bitter almonds, a cooling and then a pungent and bitter taste. It is one of the most active poisons known, a single drop being capable, when put on the skin, of causing death; and its vapor, especially to those unaccustomed to it, is highly poisonous. Its acid reaction is but slight. Powerful stimulants, like Ammonia and Alcohol are antidotes to Prussic acid.

646. **CYANID OF POTASSIUM**, KC_2N . This substance may be prepared by a variety of processes from Ferrocyanid of Potassium. It crystallizes in colorless cubes, and other forms of the first system (234) is inodorous, but gives, when in the moist state, the smell of Cyanid of Hydrogen. It is freely soluble, has an alkaline reaction, and is highly poisonous. It is employed as a solvent for the Cyanids of Silver, Gold, &c., and for removing indelible ink-marks, and the stains resulting from Nitrate of Silver. The Cyanids of the other metals of the Potassium group have similar properties.

647. **TERCYANID OF IRON**, Fe_3C_2N , is a green, light, tasteless powder, and has been called *Prussian green*.

CYANID OF MERCURY, HgC_2N , crystallizes in colorless prisms. It may be prepared from Prussian blue and red Oxid of Mercury. *Cyanid of Silver*, AgC_2N , is a white insoluble solid; and *Cyanid of Gold*, Au_3C_2N , is yellow, and also insoluble. The Cyanids of Mercury, Silver, and Gold, form double Cyanids with the metals of the Potassium group.

648. The Cyanid of Silver and Potassium, AgK_2C_2N , and the Cyanid of Gold and Potassium are very soluble salts. They are prepared by dissolving an Oxid or Chlorid of the metal in solution of Cyanid of Potassium, and are used in *electroplating* and *gilding*. The quantity of Gold or Silver in the solution employed for these purposes is maintained constant, by suspending a sheet of the metal in it from the positive pole, so that the metal is dissolved from this as fast as it is deposited upon the article to be covered attached to the negative pole.

649. **FERROCYANID OF HYDROGEN**, $FeC_2N, 2HC_2N$, or the double Cyanid of Hydrogen and Iron, has been called Hydroferrocyanic acid, is a crystallizable white solid, with an acid reaction.

FERROCYANID OF POTASSIUM, $FeC_2N, 2HC_2N$, is an important salt, often called yellow Prussiate of potash. It is manufactured on the large

643. Symb. and sources of Cyanogen? 644. Properties? Combines with what? Compounds? Name? 645. Symb., names, and sources of Cyanid of H? Properties? Poison? Acid? Antidote? 646. Symb. and preparation of Cyanid of Potassium? Crystals? Properties? Uses of KC_2N ? Other Cyanids? 647. Tercyanid of Iron? Synds. and properties of Cyanid of Mercury? Cyanid of Silver? O. Gold? 648. Properties, preparation, and uses of Cyanid of Silver and Potassium? Cyanid of Gold and Potassium? 649. Symb., names, and properties of Ferrocyanid of H? O Ferrocyanid of K?

scale from all kinds of refuse animal matters, as blood, hoofs, &c., by calcination with pearlsh and Iron filings. It crystallizes in fine yellow crystals, which are modified square octahedrons, and contain 3 equivs. of water. By a moderate heat the water is expelled, and the salt becomes nearly white. It is freely soluble in water. This salt is extensively employed in the arts, as in dyeing, making blue writing fluid, &c., and is the chief source of the other compounds of Cyanogen.

Ferric acid of Hydrogen, $\text{Fe}_2\text{C}_2\text{N}_2\text{H}_2\text{C}_2\text{N}_2$, is an unimportant substance, that has been termed *Ferricyanic acid*, and that by the replacement of its H. by K. becomes

Ferricyanid of Potassium, $\text{Fe}_2\text{C}_2\text{N}_2\text{K}_2\text{C}_2\text{N}_2$, a salt, forming fine red crystals, which are modified right square prisms.

650. It may be noticed that the Ferrocyanids contain as many equivalents of Cyanogen as of metal, or metal and Hydrogen, and that this is also true of the Ferricyanids, provided the equivalent of Iron is taken at $\frac{2}{3}$ the ordinary equivalent, that is, $\frac{2}{3}$ of 28 = 18 $\frac{2}{3}$; also, that in the Ferrocyanids there is one equiv. of Iron to two of Hydrogen or of metal, while in the Ferricyanids there are $\frac{2}{3}$ of an equiv. of Iron to one of the other element.

Laurent has proposed to give to Fe_3 the name of *Ferricum*, but this does not seem necessary.

Other Ferrocyanids and Ferricyanids, corresponding in type to those described, may be formed by reactions between metallic solutions and solutions of the two Potassium salts. Thus, with solution of Sulphate of Zinc, Ferrocyanid of Potassium gives a white precipitate of Ferrocyanid of Zinc, Zn FeCy , (using Cy. for Cyanogen), while Ferricyanid of Potassium gives, with Sulphate of Zinc, an orange yellow precipitate of Ferricyanid of Zinc, Fe_2ZnCy_2 , and so with other Oxysalts.

651. **COMPLEX CYANIDS OF IRON.** These are of a dark blue color, and are generally known as *Prussian blues*, since the ordinary article of that name was discovered in Berlin, in 1704. *Common Prussian blue* may be represented by $2\text{Fe}_3\text{C}_2\text{N}_2\text{FeC}_2\text{N}_2$. It is manufactured on the large scale from Mono-sulphate of Iron and Ferrocyanid of Potassium, and is used as a paint, but its color is not permanent. Another Prussian blue, generally called *Turnbull's*, is represented by $\text{Fe}_3\text{C}_2\text{N}_2\text{FeC}_2\text{N}_2$.

Chlorinic Cyanids. By the action of Cl. on certain Cyanids, *Bichlorinic triple Cyanid of Hydrogen*, $\text{H}_2\text{C}_3\text{N}_3\text{Cl}_2$, a volatile liquid in which Cl. replaces H. is formed. From this, a substance which may be called *Tetrachlorinic triple Cyanid*, $\text{Cl}_4\text{C}_3\text{N}_3$, a volatile crystalline solid may be formed, and also *Bichlorinic double Cyanid*, $\text{Cl}_2\text{C}_2\text{N}_2$, a volatile liquid substance.

652. *Cyanuric acid*, $\text{H}_3\text{C}_3\text{N}_3\text{O}_3$. This may be formed from Tetrachlorinic triple Cyanid, from Urea, and from several other sources. It is colorless, nearly tasteless, slightly acid, and crystallizes in oblique rhombic prisms (321), containing 4 equivs. of water. The acid is tribasic, forming a variety of salts like Phosphoric acid. From its salts it may be expelled by other acids, and from it

Cyanic acid, HCN_2O_2 may be obtained. This acid is a colorless, pungent, caustic liquid. In its salts there is a replacement of its H. by a metal.

Cyanate of Potassa, $\text{KC}_2\text{N}_2\text{O}_2$. This salt may be produced from Ferrocyanid of Potassium, and crystallizes in flat colorless crystals.

Sulphocyanic acid, HC_2NS_2 (400), is a colorless liquid, with an acid taste, and reaction obtained from its lead salt. It is of the same type as Cyanic acid, the O_2 being replaced by S_2 . Its salts are of some importance. Their composition is the same as that of the acid, except that H. is replaced by K.

Sulphocyanate of Potassa, KC_2NS_2 , is a colorless salt employed as a test for the Sesquioxide of Iron and its salts.

The Sulphocyanates are like the Sulphur salts in composition, and may be supposed to

Uses? [Ferricyanid of H. t. 650. Composition of the Ferrocyanids and Ferricyanids? Others?] 651. Complex Cyanids of Iron, and Prussian blues? [Chlorinic Cyanids; names and symbols? 652. Symb., sources, and properties of Cyanuric acid? Symb., source, and properties of Cyanic acid? Salts? Symb., source, and crystallization of Cyanate of Potassa? Of Sulphocyanic acid? Type? Salts? Symb., properties, and use of Sulphocyanate of Potassa? Composition of Sulphocyanates?

consist of a Sulphur base, as KS , combined with the anhydrous acid, C_2NS , and so with the Cyanates; thus, Cyanate of Potassa may be written, $\text{KO.C}_2\text{NO}$, and corresponds to the common type of an Oxy-salt.

Fulminates. These salts are remarkable for their explosive properties. *Fulminate of Mercury*, $\text{Hg}_4\text{C}_4\text{N}_2\text{O}_4$, is the material in the percussion-caps, and is prepared by the action of Alcohol on a solution of Hg . in Nitric acid.

Fulminate of Silver, $\text{Ag}_2\text{C}_4\text{N}_2\text{O}_4$, is prepared in a similar way; and as it explodes with great violence by friction, even if wet, is a rather dangerous compound. The explosion in these salts is the result of a decomposition into Carbonic acid, Nitrogen, metal, and metallic Cyanid.

653. There are next to be described one or two substances that connect Organic Chemistry to Inorganic, just as Ammonia and its compounds connect Inorganic to Organic Chemistry, and thus a circuit, everywhere unbroken, is formed. The first of these is

CARBONIC OXYD, CO . *Eq. 14. Sp. gr. .97. Air, 1.* This is a colorless, nearly inodorous, slightly soluble, and highly poisonous gas, which may be most easily produced by the action of Sulphuric acid on Ferrocyanid of Potassium. It is combustible, burning with a blue flame, and exploding with half its volume of O . The result of its combustion being Carbonic acid.

The burning of this gas constitutes the blue flame which is perceived when a strong Anthracite fire is covered with fresh coal, or when a powerful blast of air is driven through an anthracite fire, as with many furnaces.

The production of Carbonic Oxyd, in burning coal, should be avoided as much as possible, as it is attended by a loss of one half the heat, unless the heat from the blue flame is applied. (See Art. 353.)

Carbonic acid, which was necessarily noticed previously, is another of the substances which connect Organic to Inorganic Chemistry.

654. *Chlorocarbonic acid*, CCl_2O_2 , or *Phosgen gas*, is produced (as the term *Phosgen*, generated by light, indicates), by the action of Cl , and light on Carbonic Oxyd. It has been already referred to (610) as having the type of the aldehyd of Methol.

REVIEW.

655. The Organic portion of the subject has now received as much attention as the proposed limits of this treatise admit.

The student will mark the distinction between *organized* substances, and those that are merely *organic*. An organized substance has a peculiar structure which is the result of the action of vital forces. Animal Fibrin, or pure flesh and Cellulose, or vegetable fibre, are highly organized. In Starch, the organization is of a lower grade, though still evident; in Sugar, there is no organization, so that Sugar is merely Organic.

656. It will have been seen that the different substances in Organic Chemistry have been noticed in the following order:—

1st. Substances formed in and by plants, and which are the results of the action of vegetable vital forces. 2d. Substances constituting, or formed in the animal economy; and, also, the mutual relations of plants and animals. 3d. The results of natural decompositions, as decay, fermentation, &c. 4th. Artificial Organic substances.

657. Of these last, several groups of substances have been noticed, as: 1st. *The groups of alcohols*. 2d. *The Homologous groups of acids*. 3d. *The Soaps, Glycerids, and Ethers*. 4th. *The Aldehyds, &c.* 5th. *Artificial volatile vegetable products, as bitter almond oil*. 6th. *The Carbo-Hydrogens*. 7th. *Artificial organic alkaloids*. 8th. *Amids and nitrils*. 9th. *Artificial organic coloring matters*. 10th. *Cyanogen and its derivatives*.

THE ALLIED HOMOLOGOUS GROUPS. The groups of *alcohols, acids, ethers, dehyds, ethyls, and alkaloids, or bases*, with their wonderful variety of modification, their intimate relations to each other, and their unlimited probable derivatives, can not fail to excite in the mind of the true student the most lively sensations of admiration for the symmetrical and beautiful, if not vast proportions they display.

It will be profitable to glance once more at these groups which occupy such an important position in artificial organic Chemistry.

{ Cyanates? Fulminates, remarkable for what? Composition, use, and preparation of Fulminate of Mercury? Fulminate of Silver? Result of the explosion of the Fulminates? 653. Substances connecting organic to inorganic Chemistry? [Symb., equiv. and properties of Carbonic Oxyd? Production? Combustion and explosion? Blue flame of anthracite fires? Loss of Heat? [Symb., &c., of Chloro-carbonic acid?]

655. *Organized, organic, and examples?* 656. Order in which organic substances have been noticed? Substances noticed firstly? Secondly? Thirdly? Fourthly? 657. The ten groups of artificial organic substances, in the order in which they have been noticed? Substances embraced by the allied homologous groups?

1st. The group of *alcohols* of the formula $C_nH_{n+2}O_2$, to which Vinol, $C_4H_6O_2$, belongs.

2d. The *acids* of the formula, $C_nH_nO_4$, represented by Acetic acid.

3d. That very extensive group of substances, known as *ethers*, which is divisible and subdivisible into minor groups; first, the *primary ethers*, the formula of which may be taken as $C_nH_{n+1}O$, as common or Vinic ether, C_4H_5O .

The formula of these primary ethers is, however, most probably, $C_nH_{n+2}O_2$, or double that just given, so that they constitute a series parallel or metameric with the alcohols, and have the same type. 2d. *Ethers of the Haloid type*, as Chlorid of Vinyl, C_2H_3Cl . 3d. *Ethers of the Oxyacid type*, divisible into the two minor groups: 1st. *Ethers of the mineral acids*, as Sulphate of Vinyl, $C_2H_3O_4.SO_3$, or Sulphuric ether; and, 2d, *Ethers of organic acids*, as Acetic ether, $C_4(H_3.C_4H_5)O_4$.

4th. The group of *dehyds*, $C_nH_nO_2$, or dehydrogenated alcohols, as Aldehyd, $C_4H_4O_2$.

5th. That of *ethyls*, or *ether radicles*, as Methyl, C_2H_3 ; Vinyl, C_2H_3 ; Butyl, C_4H_7 ; Amyl, C_5H_{11} ; but the formulas for which, in the free state, should undoubtedly be doubled, making the type C_nH_{n+2} , and constituting a series of *ethyl Carbo-hydrogens*.

6th. The group of *alkaloids*, or *artificial organic bases*, of which Ammonia, NH_3 , is the type. One, two, or three equivalents of the H. of this being replaced by an ethyl, there arise the compounds, Methamin, $N(H_2.C_2H_3)$; Vinamin, $N(H_2.C_4H_5)$; Tetramethaminium, $N(C_2H_5)_4$, &c., with their salts, such as Chlorid of Vinaminium, $N.H_3.C_4H_7Cl$, and Nitrate of Methamin, or Nitrate of Oxyd of Methaminium, $N.H_3.C_2H_3O.NO_3$. In relation to these, other modifications arise in which N. is replaced by P, Sb, As, &c., and H. by Pt, &c.

The possible modifications of the members of these different groups in which there is a replacement of O. by S, &c., of H. by K, Cu, NH₄, &c., are very numerous.

In addition to these groups, there are the *amids* and the *nitrils*, besides the numerous derivatives which result from the elimination or addition of an element, by the action of various chemical agencies.

It is to be further remarked that Vinol, Acetic acid, Vinic ether, Aldehyd, Vinyl, Vinamin, Acetamid, and Acetonitril, while representatives of so many different groups, are all intimately related to each other, as is seen by comparison of their formulas, and also from their derivability, to a considerable extent, from one another. Thus, Acetic acid, Vinic ether, Aldehyd, and Vinamin, may each be formed directly from Alcohol; while Alcohol may be formed from Vinic ether; and Acetamid and Acetonitril, which are formed from compounds of Acetic acid, may, by proper means, produce Acetic acid compounds.

658. **TYPES.** A type is merely a common formula for a variety of different substances. The ordinary Sulphates, as $FeO.SO_3$, $ZnO.SO_3$, $CuO.SO_3$, and $HO.SO_3$, have all a common type which by substituting M. for Fe, Zn, Cu, or H, becomes $MO.SO_3$. The acids homologous with the Acetic, have one type, $C_nH_nO_4$.

659. **ISOMERISM.** There are, strictly, two modifications of this, namely, *metamerism* and *polymerism*.

Metamerism. By this is understood not merely that different substances may have the same elements and per cent. composition, but also precisely the *same formula*. Oil of Spirea Ulmaria, $C_{11}H_8O_4$, and Benzoic acid, $C_7H_6O_4$, are examples of metameric substances.

Polymerism. By this term is meant that different substances may have the same elements and per cent. composition, but with different formulas. In Acetic acid, $C_4H_4O_4$, Lactic acid, $C_6H_8O_6$, and Grape Sugar, $C_{12}H_{24}O_{24}$, the same elements are combined in the same ratios; but from the manner in which these substances combine, or split up, or for some other reason, it is concluded that the formulas are as just given; and these three are examples of Polymeric substances.

660. Polymorphism, and allotropism may be also regarded as modifications of isomerism; and then we have—

Isomorphism, or different substances crystalizing in the same form.

Polymorphism, or the same substance crystalizing in different forms.

Allotropism, or the same substance with different properties.

Metamerism, or different substances with identical formulas.

Polymerism, or different substances of identical composition, but different formulas.

Principles and particulars in reference to the allied homologous groups? Types? Four modifications of Isomerism? Isomorphism? Polymorphism? Allotropism? Metamerism? Polymerism?

CHEMICAL RELATIONS OF AGRICULTURE, HORTICULTURE, ETC.

661. These must have been more or less perceived in what has already appeared.

The full consideration of this subject constitutes one of the most extensive departments of the science, and can here be merely glanced at; but will be studied more fully by those who feel interested, in works especially devoted to its elucidation, as well as by means of careful and original investigation.

The rapid and healthful growth of plants depends upon conditions of two different classes. One of these embraces a proper mechanical condition of the soil, as to looseness, moisture, the relations of locality and climate, &c.; with these Chemistry has but little to do.

The other class of conditions is purely chemical. These are the proper composition of the soil, and the right administration to it of such substances as may improve its composition, and favor the more rapid growth of plants.

662. *Composition of Soils.* Soils consist for the most part of variable mixtures of Silica or sand, Silicate of Alumina or clay, and partially decomposed organic matter. As the ratios of these vary, the soil is suited to one or another description of crop, as every husbandman understands.

But while plants take most of their material from the atmosphere, or at least from gases, or other fluids, they require small quantities of Potassa, Soda, Lime, Phosphoric acid, &c., which enter into their composition (as noticed, 365), and the presence of which is indispensable to their healthful growth. These must always be present, in sufficient quantity, to render a soil fertile.

663. Besides this, certain plants require, as is learned by their analysis, and that of the soil in which they best flourish, a *preponderance* of certain of these mineral elements.

All these subjects, as well as the composition and growth of plants, and their products, can not be understood, without a knowledge of Chemistry; and hence it becomes necessary that every person, directly interested in the culture of the soil, should have a very considerable amount of Chemical information.

APPENDIX.

664. ACIDS OF THE FORMULA, $C_nH_{2n}O_4$. 6th, Caproic, $C_6H_{12}O_4$; 11th, Margaritic, $C_{22}H_{42}O_4$; 12th, Laurostearic, $C_{24}H_{48}O_4$; 13th, Cocinic, $C_{26}H_{52}O_4$; 14th, Myristic, $C_{28}H_{56}O_4$; 19th, Balenic, $C_{38}H_{76}O_4$; 21st, Behenic, $C_{42}H_{84}O_4$; making the series complete to the 30th, excepting the 20th, 22d, 23d, 24th, 25th, 26th, 27th, 28th, and 29th.

665. *Aluminum.* This metal seems to be acquiring considerable importance. Although its existence was recognised many years ago, it is but recently that its properties have become fully understood. It is a fine silvery metal, not oxydized by atmospheric influences, but resembling Tin and Silver in this respect: fusing only at a high temperature like Silver, and not acted upon sensibly by such acids as the Nitric and Sulphuric. Hence, if it can be isolated, economically, it promises to be a very valuable and common metal. In the course of the operation required for its isolation, Sodium is employed by the French Chemists, and, in consequence, this hitherto very costly metal, has been produced in the large way for less than a dollar a pound.

666. *Hydraulic Cement, Artificial Stone, &c.* It seems to be probable from the recent investigations of Kuhlmann that the hardening of this class of substances, is the consequence of the presence of Silicates of Potassa and Soda, which, from the action of natural Chemical agents, are converted from a somewhat soluble to other insoluble and permanent stony Silicates.

667. *The isolation of the Radicles of the Ethers.* Methyl, C_2H_6 ; Vinyl, C_4H_6 ; Butyl, C_8H_{18} ; Amyl, $C_{10}H_{22}$; Caproyle, $C_{12}H_{26}$; have all been recently isolated, and various compounds of one with another have been formed. The formulae above given for these radicles, when free, will probably be doubled. See *Compte Rendu*, June 18, 1855.

661. Chemical relations of Agriculture, &c.? Two classes of conditions favoring the growth of plants? Chemical conditions? 662. Principal constituents of oils? Principal source of material for plants? Other substances indispensable? 663. Certain elements must preponderate? Why necessary to understand Chemistry.

GLOSSARIAL INDEX.

Abies Canadensis.....Art.	422	Appendix.....Art.	684	Calcined Mg.Art.	173
Acer saccharinum.....	372	Aqua fortis.....	218	Calcite.....	110
Acetum oile.....	429	Aqua regia.....	141, 156	Calcium.....	110
Acetamid.....	694	Archil.....	637	Calcespar.....	234
Acetate of Alumina.....	563	Argol.....	420	Calomel.....	154
" Copper.....	565	Arrow root.....	52, 376	Camphen.....	407
" Lead.....	564	Arsenacetic acid.....	632	Camphor.....	406
" Soda.....	562	Arsenic.....	130, 242	Camphoric acid.....	577
Aceten.....	621	Arsenious acid.....	242	Cane sugar.....	372
Acetic acid.....	559	Asenotermethammin.....	530	Cantharidin.....	470
" Ether.....	600	Asphaltum.....	64, 530	Caoutchouc.....	410
Aceto-amylic.....	606	Assaying.....	275	Captaaries.....	503
Acetomethyllic ".....	604	Ashes.....	364	Capric acid.....	567
Aceton.....	612	Atom-ic theory.....	352	Caprin, Caproin.....	467
Acetonitryl.....	635	Attraction.....	302, 320	Caproic acid.....	664
Acetous fermentation.....	526	Baking soda.....	233	Caprol.....	570
Acids.....	31, 285	Balenic acid.....	684	Caprylic acid.....	567
Acrylic acid.....	573	Balloon.....	77, 544	Carbon.....	62
Adipic acid.....	575	Balsams.....	409	Carbonate.....	226
Aeromantics.....	87	Baryta.....	171	" of Ammonia.....	261
Afinity.....	10, 302, 342	Bases.....	34	Carbo-Hydrogen.....	530, 549, 617
Agriculture.....	661	Bassic acid.....	568	Carbonic acid.....	2, 226
Alumin.....	125, 154, 382, 439	Battery Grove.....	334	" ether.....	549
Alcohol.....	551	Bee-wax.....	462	" oxyl.....	161, 653
Alcoholic fermentation.....	526	Behenic acid.....	664	Carburets.....	45, 119
Aldehyd.....	607	Benzen.....	620	Carburetted H.....	534
Alkalis.....	34, 94, 98, 102, 171	Benzoic acid.....	453, 576	Carburet of N. is Cyanogen	
Alkaline substances.....	94	Benzoin.....	614	Cardiac orifice.....	496
Alkalis.....	302, 621	Benzoiol.....	613	Carmine.....	174
Alkarsin.....	632	Benzol.....	620	Cartilage.....	478
Alkarsin.....	632	Benzol.....	571	Cassia.....	440
Alkarsin.....	442	Beta vulgaris.....	372	Cassava.....	432
Alotropism 21, 65, 277, 309, 660		Bis-basic acid.....	201	Castor oil.....	405, 574
Alloy.....	118	Bisulphate Soda.....	237	Cast Iron.....	119
Almond oil.....	613	Bichromate.....	239	Catalysis.....	510
Alum.....	115, 214	Bile.....	489	Celestine.....	109
Alumina.....	115, 174	Biliary calculi.....	469	Cellular tissue.....	480
Aluminum.....	115, 685	Bismuth.....	628	Cellulose.....	369
Amalgam.....	131	Binaries.....	135	" Nitrous.....	636
Amid.....	634	Binary oils.....	406	Cement.....	173, 666
Amidogen.....	634	Binoxid of Mn.....	176	Ceretic acid.....	459
Ammonia.....	247, 510, 624	Bismuth.....	123	Ceritol.....	570
" Bisulphidic.....	267	Bismuth.....	629	Cerin.....	471
" Trichloric.....	266	Bismuth.....	629	Cerium.....	113
" Monopotassic.....	268	Black ead.....	62	Cerotic acid.....	471, 563
" Ammoniac.....	253	Bacelling.....	20	Chalk.....	61, 179
" Sulphate of Cu.....	5	" powder.....	22, 204	Cha ybeate.....	167
Ammonium.....	253	Blende.....	123, 190	Charcoal.....	62, 165
Ammonium.....	400	Blood.....	481	" is mostly Casein	
Ammonium.....	400	Boric acid.....	74, 237	and butter.	
Ammonium.....	400	" ether.....	590	Chemical solution.....	5
Ammonium.....	400	Borax.....	74, 237	Chemistry Inorganic.....	1, 246
Ammonium.....	629	Boron.....	74	" Objects, operations 3, 272	
Ammonium.....	617	Bones.....	476	" Or-anic.....	246, 361
Ammonium.....	605	Brain.....	492	Chloral.....	610
Ammonium.....	557	Brassica.....	405, 616	Chloracetic acid.....	565
Ammonium.....	169	Bread-making.....	522	Chlorate of Potassa.....	202
Ammonium.....	135	Brantstone.....	42	Choric acid.....	202
Ammonium.....	273	Britanna.....	129	Chloride.....	19, 135
Ammonium.....	457	Bromide.....	15, 135, 137	" of Ammonium.....	234
Ammonium.....	450 to 460	Bromine.....	14	" " NH ₄ and PL.....	255
Ammonium.....	450	Bromohydric acid.....	137	" " NH ₄ -Cu. etc.....	623
Ammonium.....	462	Bronze.....	127	" Carbon.....	618, 623
Ammonium.....	571	Burned alum.....	214	" Hydrogen.....	138
Ammonium.....	566, 619	Burning.....	30	" Manganese.....	17
Ammonium.....	62, 532	" fluid.....	407	" Metes.....	147 to 156
Ammonium.....	573	Butter, 463, 467, Butyren.....	617	" Nitrogen.....	266
Ammonium.....	129	Butyric acid.....	566	Chlorimetry.....	275
Ammonium.....	192	Butyren.....	467	Chlorine.....	2, 17
Ammonium.....	548	Cadmium.....	123	Chloroserit.....	469
Ammonium.....	54, 225	Caffeine.....	395	Chlorite.....	111
Ammonium.....	54, 225	Calamine.....	236	Chlorocarbonic acid.....	654

- Chlorochromic acid... Art. 241
 Chloroform..... 619
 Chlorohydric acid..... 188
 Chocolate..... 543
 Choke damp..... 238
 Cholic acid..... 454
 Choleic "..... 461
 Cholic "..... 457
 Chondrin..... 443
 Chromates..... 239
 Chrome green..... 120, 181
 Chromic acid..... 238
 Chromium..... 120
 Chyle..... 490
 Chylification..... 497
 Chymification..... 496
 Cider Vinegar..... 560
 Cinnabar..... 131, 193
 Cinnamic acid..... 578
 Cistern..... 17
 Citric acid..... 421
 Citrus Limonium..... 421
 Clay..... 115
 Coal..... 63, 539
 Coal gas..... 540
 Coal oil..... 542
 Cobalt..... 122
 Cocaine..... 174
 Cocinic acid..... 664
 Coffee..... 395
 Coke..... 512
 Colcothar..... 179
 Coilodon..... 636
 Colophony..... 409
 Columbium..... 126
 Combination..... 4, 303, 348, 359
 Combustion..... 84, 90
 Common salt..... 100, 148
 Compound radicle..... 597
 Compounds..... 7, 135
 Conduction..... 92
 Copal..... 409
 Copper..... 125
 Copperas..... 215
 Copper glance..... 191
 Coral..... 64
 Corrosive sublimate..... 154
 Cream of tartar..... 231, 420
 Creatin-in..... 446
 Crystals, etc..... 320
 Cube..... 321
 Cudbear..... 637
 Cumen, Cymen..... 620
 Cumic acid..... 576
 Cuminol..... 571
 Cyan-ic, uric acid..... 652
 Cyanogen..... 643
 Cyanids..... 645 to 651
 Daguerreotype..... 16, 146, 205
 Davy's lamp..... 537
 Decomposition..... 4, 341, 359
 Definite ratios..... 345
 Deglutition..... 496
 Deliquescence..... 150
 Delphinin..... 468
 Density..... 14
 Derbyshire spar..... 21
 Deseccation..... 150
 Dextrin..... 519
 Diamond..... 62
 Diastase..... 519
 Dieline..... 326
 Didymium..... 134
 Diffusion..... 79, 278, 307
 Digestion..... 494
 Dimetric..... 325
 Dimerphism..... 44, 277, 325
 Disinfection..... 22
 Distillation..... 165, 553
 Dodecemer jur..... 395
 Dodecahedron..... 322, 324
 Dœglic acid..... Art. 573
 Drummond light..... 85
 Drying oils..... 405
 Ductility..... 93
 Duodenum..... 497
 Earths..... 114, 174
 Effluence..... 164, 211
 Eggs..... 125, 154, 493
 E. acid..... 573
 Electricity..... 334
 Electric telegraph..... 1
 Electrolysis..... 341
 Electro plating, etc..... 346, 643
 " metallurgy..... 346-7
 " positive, etc..... 350
 Emerald, Emery..... 115
 Eranthylic acid..... 567
 Epsom salts..... 107, 124, 213
 Equivalents..... 13, 316
 Erbium..... 134
 Eremacausis..... 511
 Esophagus..... 496
 Essential oils..... 406
 Etching..... 25, 143
 Ethalic acid..... 567
 Ethers..... 583
 Ethyl..... 570
 Ethyl..... 565
 Eudiometer..... 275, 315
 Eupion..... 549
 Exhilarating gas..... 156
 Exuviae..... 252, 491, 507
 Fats..... 403, 462-9, 508
 Feldspar..... 71, 95, 115
 Fermentation..... 517 to 529
 Ferric acid..... 180
 Ferri-cyanids..... 649
 Ferruginous water..... 167
 Fibre..... 382, 438
 Fire 4, 354, damp..... 586
 Filtration..... 166
 Fixed..... 89, 384, 404
 Flame..... 81, 543
 Flesh fluid..... 486
 Flint..... 196
 Flowers of S..... 42
 Fluids..... 143
 Fluohydric acid..... 25, 143
 Flour consists of Starch,
 Glutin, Sugar, Albumin,
 and salts.....
 Fluorids..... 135-6, 151
 Fluorine..... 24
 Fluorspar..... 150
 Fool's gold..... 190
 Formen..... 534
 " Terchloriatic, etc..... 619
 Formic acid..... 450, 558
 Fulminates..... 632
 Galena..... 124, 191
 Gall nuts..... 422
 Galvanic battery..... 86, 534-47
 Gases..... 432
 Gas pistol..... 80
 Gastric juice..... 452, 495
 Gaultheria procumbens..... 619
 Geline..... 536
 Gelatin..... 442
 German silver..... 121
 Glasses..... 197
 Glauber's salts..... 211
 Glucina..... 175
 Glucinum..... 115
 Glucose..... 375
 Glue..... 442
 Glutin..... 438
 Glycands..... 562
 Glycerin..... 470, 582
 Glyceoll..... 693
 Gof. L..... 132
 Grain..... 52, 73, 532
 Granite..... Art. 71, 115
 Graphite..... 62, 532
 Guano..... 60
 Gum..... 52, 377, 410
 Gun cotton..... 636
 " powder..... 46, 68, 220
 Guts Percha..... 411
 Gypsum..... 42, 207, 212
 Gyrophora murina..... 637
 Hair..... 492
 Haloids..... 26, 135, 145-56
 Hartshorn..... 27, 261
 Heat..... 92, 350-60
 Heavy spar..... 106
 Hematosin..... 448
 Hevea Guianensis..... 410
 Hexagonal..... 65, 321 and 7
 Hippuric acid..... 456
 Hircin..... 467
 Homogenous light..... 143
 Honey..... 375
 Hoofs, horns..... 492
 Horticulture..... 661
 Howe's cave..... 235
 Humus..... 530
 Hydracids..... 26, 135, 7
 Hydrates..... 169
 Hydrochloric acid..... 141
 Hydrocyanic acid..... 645
 Hydrogen..... 2, 76
 Hydro-oxygen blowpipe..... 85
 Hydrous..... 169
 Hyocholic acid..... 437
 Hypochlorite..... 204
 Hyponitric acid..... 159, 218
 Hypophosphorus acid..... 222
 Hyposulphite..... 205
 Iceland spar..... 231
 Imerium..... 134
 Imponderables..... 358
 Incandescence..... 81
 Indian corn..... 52
 Indigofere..... 639
 Indigo-gen..... 639, 640
 "..... 20, 133, 221
 Ink..... 495
 Ino-inic acid..... 458
 Inealivation..... 495
 Iodids..... 10-12, 146, 152
 Iodine..... 9
 Iodoform..... 619
 Iridium..... 132
 Iron..... 118-19
 Isatin..... 641
 Isatis tinctoria..... 639
 Isinglass..... 443
 Isomerism..... 380, 617, 659, 660
 Isomorphism..... 531, 660
 Isomandra gutta..... 411
 Jack o' Lantern..... 194
 Jatropa elastica..... 410
 " Manihot..... 432
 Kall..... 96
 " Kakodylic acid..... 631-2
 Kresote..... 548
 Lactic acid..... 452, 493, 496, 659
 Lactose..... 444-5, 452
 Lakes..... 174
 Lanthanum..... 113
 Land (See fats)..... 573
 Laughing gas..... 138
 Laurostearic acid..... 664
 Laurus camphora..... 406
 Lead..... 124
 Leaden chamber..... 207
 Leaf green..... 401
 Lean meat..... 438
 Lecanoma percha, etc..... 647
 Legumin..... 382
 Ligaments..... 490
 Light..... 89, 351-2
 Lignite..... 61, 532

- Lime Art. 110, 173, 204
 Limestone..... 64, 110-11, 173
 Limonite..... 118
 Linseed..... 377
 Linum usitatissimum..... 405
 Liquid..... 9
 Litharge..... 63, 125, 142
 Litho-mica..... 32-34, 98, 6-7
 Lodestone..... 173
 Lunar caustic..... 221
 Lye..... 95
 Madder..... 402
 Magnesia..... 111, 173
 Magnesium..... 111
 Magnet, -ite, -ism..... 118, 121, 178
 Malic acid..... 421
 Maleability..... 93
 Mal 519
 Mal-grease..... 117
 Maranta arundinacea..... 432
 Marble..... 64, 234
 Marcasite..... 190
 Margarin..... 568
 Margarin..... 404, 465
 Margaritic acid..... 664
 Marsh gas..... 534
 Mastic..... 100
 Mastication..... 495
 Matches..... 46, 59
 Meat (see lean meat and
 flesh fluid).
 Melissic acid..... 568
 Mellisool..... 570
 Membrane..... 480
 Mercaptan..... 603
 Mercury..... 131
 Metacetic acid..... 566
 Metal..... 8, 92-134
 Metamerisin..... 659
 Meteoric Iron..... 118
 Methanum..... 627
 Methammonium..... 627, 657
 Metharsammen..... 631
 Method of Mixtures..... 556
 Methol 552. Methyl..... 657, 667
 Methyl ethers..... 604
 Mica..... 95
 Microcosmic salt..... 260
 Milk..... 485
 Mineral water..... 167, 229
 Mineralizer..... 118
 Molasses..... 372
 Molybdenum..... 126
 Monobasic acids..... 201
 Monoclinic system..... 326
 Monometric system..... 324
 Mordant..... 153, 174
 Moringia aptera..... 573
 Moringic acid..... 573
 Mortar..... 173
 Morphine..... 393
 Mucilage..... 377
 Multiple ratios..... 317
 Muratic acid..... 141
 Muscle..... 479
 Myrica cerifera..... 462
 Myrcin..... 471
 Myristic acid..... 664
 Naphen..... 647
 Naphthalen..... 98, 531, 552
 Naphthalen..... 549, 626
 Nascent state..... 136, 309
 Nat. veg. acids and salts..... 412
 Native metal..... 110
 Natrium..... 100
 Nerves..... 492
 Neutral Ternaries..... 368
 " Quaternaries 381, 496
 Nickel..... 121
 Nicotiana Tabacum..... 397
 Nicotine..... Art. 397
 Nicotium..... 144
 Nitrates..... 218-21
 " Ammonia..... 258
 " Methanmin..... 628
 Nitre..... 48, 220
 Nitric acid..... 214
 Nitrogen..... 2, 14
 Nitro-margaric acid..... 114
 Nitrous acid..... 159, 218
 Nitrile..... 635-6, 657
 Noble metals..... 131
 Nomenclature..... 2, 279
 Non-metals..... 8, 88
 Nordhausen acid..... 209
 Nourish..... 134
 Nucleotide..... 444
 Ochres..... 173
 Octahedron..... 3, 44, 322-6
 Oils and fats, animal..... 462-73
 Artificial, mustard, etc. 613-18
 Natural vegetable..... 403-8
 Oil of Roses..... 618
 " Vitriol..... 203
 Olea Europea..... 405
 Olefiant gas..... 536
 Oleic acid..... 573
 Olein..... 404, 464
 Opium..... 365
 Opposing action of plants
 and animals..... 510
 Ore..... 118
 Organic elements..... 364
 Organic and organized..... 655
 Orpiment..... 192
 Osmium..... 126
 Oxacids..... 30, 193-8
 Oxalates..... 416-18
 Oxalic acid..... 412
 Oxalis..... 412
 Oxamid..... 634
 Oxid..... 30, 33, 157
 " of Ammonium..... 253
 " Carbon..... 161, 226, 653
 " Metals, K, Al, etc. 171-5
 " " Fe, Sn, Hg.
 etc. 176-85
 " " Metharsammen..... 632
 " " Non-metals..... 158-70
 " " Vinyl 505, 598, 657, 667
 Oxygen..... 2, 27, 309
 Oxyalts..... 30, 198, 590-4
 Ozone..... 949
 Palladium..... 131
 Pancreatic juice..... 487
 Papaver somniferum..... 393
 Paraffin..... 532
 Peat..... 61, 532
 Pearlash..... 231
 Peculiar principles..... 399, 444
 Pelargonic acid..... 567
 Pelargonium roseum..... 567
 Pelopium..... 134
 Pepsin..... 417
 Percussion caps..... 652
 Petroleum..... 531
 Phenol..... 571
 Phloridzin..... 406
 Phocenin..... 468
 Phosgen gas..... 610, 651
 Phosmethammin..... 630
 Phosphates..... 53, 221-5
 " Ammonia, Am. and
 Soda..... 259-60
 Phosphorescence..... 57, 151
 Phosphoric-ous acid..... 222
 Phospho-rous urets..... 53
 Phosphuretted H..... 194
 Photography..... 12, 16
 Pimaric acid..... 409
 Pimelic acid..... 575
 Pinic acid..... Art. 409
 Plaster of Paris..... 212
 Platinammonium..... 626
 Platinum..... 83, 132
 " sponge..... 83, 156
 " black..... 559
 Plumbago..... 62
 Poles of battery..... 338
 Polymerism..... 659
 Polymorphism..... 328, 660
 Porcelain..... 197
 Positive pole, etc..... 338-45
 Potash..... 95, 231
 Potassa..... 96, 172
 Potassium..... 2, 95
 Precipitation..... 6, 185, 624
 Prisms..... 44, 65, 321, 333-7
 Propionic acid..... 566
 Protein..... 416, 431, 635
 Products, artificial, organic 539
 " natural animal..... 496
 " vegetable 367
 Products of natural decom-
 position..... 550
 Protoplasm..... 386, 390, 425
 Prussian blue..... 133, 651
 " green..... 647
 Prussiate of Potash..... 649
 Pulverization..... 272
 Putrefaction..... 512
 Pyrites..... 136-1
 Pyroligneous acid..... 547, 561
 Pyrotechny..... 109
 Pyroxylic spirit..... 552
 Pyrus Malus..... 421
 Quartz..... 71, 196
 Quarternaries..... 201, 381, 436
 Quadribasic..... 201
 Quercus infectoria..... 422
 Quicksilver..... 131
 Quinine..... 634
 Radicles..... 597, 667
 Raphides..... 430
 Ratios..... 314-18
 Ratsbane..... 130, 242
 Reagent..... 11
 Realgar..... 192
 Remet..... 440
 Resins..... 409
 Respiration..... 38, 503
 Rhodium..... 131
 Rhombohedral system..... 327
 Rhus..... 422
 Ricino-leic, -olic acid..... 574
 Ricinis communis..... 405, 574
 Rocella..... 637
 Rochelle salt..... 420
 Rock candy..... 574
 " crystal..... 196
 " oil..... 531
 Rouge..... 179
 Rubia tinctoria..... 402
 Rumex..... 412
 Ruthenium..... 134
 Saccharum officinarum..... 372
 Sago..... 370
 Sagus..... 432
 Sal-aeratus..... 231
 " ammoniac..... 142, 254
 " prunelle is Nitrate of
 Potassa.
 " soda is Carbonate of
 Soda.
 " volatile..... 261
 Salix..... 400
 Salt of Lemon is Citric acid.
 " sorrel..... 416
 " tartar..... 331
 " vitriol is Sulphate
 of Zinc.
 Saltpetre..... 220

- Salts, Haloid.... 26, 135, 145-56
 Salts, Oxy-..... 198, 590-4
 Salt sedative is Boracic acid.
 Salts of Vegetable acids... 412
 Salts Sulphur..... 244
 Sanguification..... 499
 Sapphires..... 115
 Saxon blue..... 641
 Sebaceous acid..... 575
 Selenium..... 46
 Seneca oil..... 581
 Serolin..... 469
 Serpentine..... 71, 111
 Shells..... 64
 Siccrescent oils..... 429
 Silica..... 196
 Silicic-acid..... 196, 237
 Silicium..... 92
 Silicon..... 71
 Silver 132, horn..... 155
 Silvic acid..... 409
 Simple substances... 7, 134, 313
 Sinapis C H N₂ is from oil of Mustard.
 Sinapis nigra..... 616
 Sinapis..... 372
 Skin..... 49
 Slate..... 145
 Smalts..... 122
 Soaps..... 580
 Soda 102, 178, ash..... 292
 Soda water..... 229
 Sodium..... 100, 665
 Soils, composition of,.... 662
 Solder..... 127
 Solids..... 9
 Solution..... 5, 367
 Specific gravity 8, heat... 335
 Spermaceti..... 567
 Spiræa Ulmar..... 615
 Spirit of Salt 17, 141, -wood 552
 Spirits of hartshorn..... 250
 Spirit of wine is Alcohol.
 Spodumene..... 105
 Stalactites, Stalagmites... 235
 Starch..... 52, 370, 378, 474
 Stearic acid..... 568
 Stearin..... 466
 Steel..... 119
 Stibtermethammin..... 630
 Strontianite, um..... 109
 Strychnine, osnux vomica 396
 Styra benzoin..... 458
 Suber, -ic acid..... 575
 Sublimation..... 42, 154, 254
 Succinic acid..... 575
 Suet..... 467
 Sugar..... 52, 372-6
 " of glue 633, Lead..... 564
 " " milk..... 444
 Sulphate..... 41, 210-17
 " of Ammonia..... 257
 " " Methyl..... 604
 " " Vinyl..... 585, 598
 Sulphindyllic acid..... 641
 Sulphite..... 206
 Sulphocyanic, etc..... 460, 652
 Sulphopurpuric, etc..... 641
 Sulphovinic, etc..... 588
 Sulphur..... 41
 Sulphur aldehyd..... Art. 610
 Sulphurets..... 41, 186-93
 Sulphurated H..... 187
 Sulphuric acid..... 207
 Sulphurous acid..... 45, 206
 Sulphur salts..... 244
 " waters..... 167, 189
 Sulphydrate of Ammonia... 264
 Sulphhydrates..... 244
 Sulphydric acid..... 187
 Superphosphate..... 60
 Sycite 71, Sylvine..... 147
 Symbols..... 298, 318
 Talc..... 71, 111
 Tallow..... (See 462, 465)
 Tannic acid, -in, -ing..... 422
 Tantalum..... 126
 Tapioca..... 370, 432
 Tactar emetic..... 420
 Tartaric acid Tartrates 419-20
 Tea..... 395
 Tellurium..... 46
 Tenacity..... 93
 Tendons..... 480
 Terbium..... 134
 Terchloride, etc., Formen 619
 Termethammin..... 628
 Ternary acids..... 450
 " compounds..... 193
 " oils..... 406
 Tervinammin..... 629
 Test..... 11
 Theobroma Cacao..... 395
 Theobromine..... 395
 Thionuric acid, C₂H₃N₃S₂
 Oil, is derived from Uric acid.
 Thoracic duct..... 498
 Thoria 175; -um..... 113
 Tin-plate 127, -putty..... 184
 Tissue..... 442, 480
 Titanium..... 126
 Tobacco..... 397
 Toluene..... 620
 Toluic acid..... 576
 Torreya taxifolia..... 418
 Tournesol..... 637
 Tribasic oxacids..... 201, 327
 Triclinic system..... 325
 Trimetric..... 325
 Trimorphism..... 328
 Tungsten..... 126
 Turneric..... 98
 Turnbull's blue..... 651
 Turpentine..... 19, 407
 Type metal..... 129
 Types, chemical..... 658
 Ultimate atoms..... 332
 Ultimate elements are simple elements.
 Uranium..... 116
 Urea 449, Uric acid..... 455
 Urine..... 491
 Urtica urens..... 450
 Vacuum pans..... 373
 Valeriana officinalis..... 566
 Valeric acid..... 566
 Valero-amylic ether..... 605
 Vanadium..... 126
 Vapor..... 9
 VEGETABLE acids and salts 412
 " Albumin, Casein,..... 382
 " Filicin, Gelatin..... 382
 " alkaloïds..... 392
 " components..... 367
 " decay..... 511, 530
 " mould..... 530
 " oils and fats..... 403
 " ultimate elements 362, 365
 Verdigris..... 365
 Vermilion is HgS.
 Vinamin..... 629
 Vinegar..... 559
 Vinic aldehyd..... 607
 " ether..... 584, 601
 Vinol 553, Monopotassic... 603
 Vinous fermentation..... 520
 Vinyl fermentation..... 595, 629
 Vitriols..... 208, 215-17
 Volatile substances..... 89
 " organic elements 364
 " vegetable oils..... 466
 Voltaic circuit..... 334
 Vulcanized Caoutchouc... 410
 Water..... 162
 An organic element, 473;
 Ammonia, 259; basic
 water, is water as a
 base (See 267, 222-7);
 boiling, 163; crystallization, 164; Chalyb.,
 167; decomposed, 162,
 343-5; distilled, 165;
 ferruginous, 167; form-
 ing 31, 38, 40, 86; free-
 zing, 163; hard, 162;
 Lebanon, 167; Lime,
 173; at maximum or
 greatest density, 163;
 mineral, 167, 229; puri-
 fication, putrid, 166;
 rain, 165; relations to
 life, 510; Salina, sea,
 148; Soda, 229; soft,
 168; Solvent, 164; Sul-
 phur, 167.
 Waste and supply..... 502
 Wax..... 462
 Will-a-wisp..... 194
 Wine..... 229
 Wine fermented contains
 Alcohol..... (See 524)
 Wine vinegar..... 560
 Wintergreen..... 615
 Witherite..... 106
 Whey..... 444
 White arsenic, 130, 242;
 lead, 236; paint, 85, 108,
 123; precipitate, 625.
 Wolframum, see Tungsten.
 Wood, 431; distillation,
 547; Naptha, 552; tar,
 547.
 Xanthin..... 402
 Yeast..... 518
 Ytri-a, 175; -um..... 113
 Zaffre..... 152
 Zinc..... 123, 181
 Zirconia 175; -um..... 113

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